SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1920.

GENERAL PHYSICS.

275. *Apparatus for Measurement of Sliding Friction.* **J. Andrade.** (Comptes Rendus, 169. pp. 638-639, Oct. 13, 1919.)—The apparatus consists of: (1) A solidly made balance, in which the distances of the knife-edges supporting the scale-pans are accurately known, and having rigidly attached to its beam a plane to carry a second knife-edge which, when the balance is in equilibrium, will be vertically above the line of suspension. The distance between the knife-edges must be accurately known; (2) the beam of a lighter balance without scale-pans, the under surface of which, on both sides of the knife-edge, forms portions of a plane passing through the knife-edge, and is balanced so that when the primary balance is in equilibrium, the secondary beam will be horizontal. A slider of weight q is provided for the latter, and its weight balanced by the reaction of a cylinder of the substance whose sliding friction with the plane surface of the beam is to be determined. The cylinder is then made to rotate at any desired speed, when weights, which will be greater the greater this speed, will have to be placed in one or other of the scale-pans in order to restore equilibrium. From these data the coefficient of friction can be determined. The method is found to be applicable over a very wide range of speed. G. W. DE T.

276. *Mirror Extensometer for Testing Wire.* **T. D. Lynch and P. H. Brace.** (Eng. News-Record, 83. p. 32, July 3, 1919. Paper read before the Am. Soc. for Testing Materials.)—Light from a single filament galvanometer strip is reflected successively from two mirrors fastened to two rollers in contact with the specimen, on to a curved scale. Changes of length of 1/50,000 in. can be determined. F. C. A. H. L.

277. *Tide-predicting Machine.* (Engineering, 108. pp. 882-884, Dec. 19, 1919.)—The machine here described was recently constructed by the firm of Kelvin, Bottomley and Baird, Ltd., for the Argentine Naval Commission, for the purpose of computing the tides on the Argentine coast. It is of the type originally designed by Kelvin, and is, generally, similar in principle to the machines previously supplied by the firm to the French, Brazilian, and Japanese Governments. The machine provides for sixteen harmonic components. Detailed drawings are given of one component, and there is also a full description and photograph of the complete machine, with a table of data for the 16 components. A. W.

278. *Apparatus for Gas-flow Measurement.* **N. W. McLachlan.** (Phys. Soc., Proc. 32. pp. 1–20, Dec. 1, 1919.)—A meter for the measurement of the flow of gases is described. It consists of a vane moving against a spring, and upon the vane the gas, issuing through a nozzle, impinges. The theory of the instrument is investigated, the effects of variation in the gas temperature and pressure being taken into consideration. This theory is tested experimentally over a range of pressures varying from 1250 to 250 mm. of mercury; and over a temperature range of 10° to 100° C. It is found to be fairly accurate. The results are applied to the rate of atmospheric flow on an aeroplane in the upper atmosphere, where a reduction of temperature and pressure is encountered. It is shown that the instrument reading for a certain N.T.P. volume of the gas depends on the altitude, but that this volume can be obtained by using a correction factor. W. A. R.

279. *The Brown Gyro-Compass.* **S. G. Brown.** (Engineering, 119. pp. 202–206, Feb. 13, 1920. El. Rev. 86. pp. 203–205, Feb. 13, 1920. Nature, 105, pp. 44–48, March 11, and pp. 77–80, March 18, 1920. Paper read before the Roy. Inst.)—A full description, with ten illustrations, of the Brown gyro-compass, this instrument being compared and contrasted with those due to Anschütz and to Sperry. For details the original should be consulted. E. H. B.

280. *Vapour-free Vacuum Seal.* **A. H. Pfund.** (Nat. Acad. Sci., Proc. 5. pp. 521–522, Nov., 1919.)—In order to overcome the defects exhibited by the ordinary stop-cock when a very high vacuum has to be reached and maintained, a modification of the well-known trap has been designed which is tight and vapour-free, allows of the use of large openings, and permits of the re-exhaustion of apparatus which has become gassy without the admission of air. A sketch of the apparatus is given in the original paper. T. H. P.

281. *A Continuous Family of Terminal Curves of the Regulating Spiral constructed by means of Points and Tangents.* **M. Aubert.** (J. de Physique, 9. pp. 68–78, Feb., 1919.)—Huyghens was the inventor of the spiral spring and the first paper on the related theory was published by Berthoud in 1773. Le Roy in 1770 was the first to discover experimentally the possibility of realising isochronism by a convenient choice of extremities, although it was reserved for Phillips in 1861 to formulate the necessary and sufficient conditions which the terminal curve of the spiral should satisfy to ensure isochronism of oscillations. Phillips' memoir is first discussed in the present paper, in particular his method for finding graphically the terminal curves for each separate case. The present investigation has for its object the study of a group of terminal curves which may be constructed by points and tangents, and whose equation in polar coordinates includes two parameters which permit of subjecting them to a supplementary condition other than that due to Phillips, the set of such curves forming a continuous family. The particular curve chosen for investigation is the logarithmic spiral $\rho = ae^{b\theta}$, whose tangent at each point makes with the radius vector a constant angle V such that $\tan V = 1/b$. Several tables and diagrams are included in the paper. H. H. Ho.

282. *Determination of Mean Accidental Variations in Daily Rates of a number of Chronometers.* **N. Liapin.** (Roy. Astron. Soc., M.N. 80. pp. 64–69, Nov., 1919.)—The author is dealing with well-compensated chronometers (or clocks) whose variations are purely accidental and oscillate within certain limits. He defines the *quality index* as the square root of the quadratic mean of independent differences of a sufficient number of daily rates. This index, which he regards as practically a constant for a given chronometer, should not exceed ¼ second. Taking a large number of chronometers, he obtains a sort of fictitious mean chronometer, regarded as practically perfect, and compares the separate ones with this, giving an alternative method in cases where the first fails, *e.g.*, when one of the chronometers is more perfect than the fictitious mean one, or has a systematic periodic variation. W. W. B.

283. *Struve's Empirical Formulæ for Corrections of Clocks, etc.* **N. Liapin.** (Roy. Astron. Soc., M.N. 80. pp. 70–71, Nov., 1919.)—W. Struve gave as the result of many observations empirical formulæ for the errors of extrapolated and interpolated corrections of clocks or chronometers due to the accidental variations in their daily rates. The author establishes these from the theory of errors only. W. W. B.

284. *Investigation of Strains in the Rolling of Metal.* **A. Musso.** (Am. Soc. Mech. Eng., J. 41. pp. 937–938, Dec., 1919.)—If b is the angle made by the line joining the point of contact of metal and roll with the centre of the roll and the line of centres of the rolls, the applied pressure P may be resolved into two components, one, P sin b, along the surface of the metal and hindering this from entering the rolls, the other P cos b which produces the actual compression. Unless the latter is greater than the former, *i.e.*, b is less than 45°, the rolls will not grip the piece. The coefficient of friction between roll and metal is about 0·577 so that the max. practical value of b is $\tan^{-1}0{\cdot}577 = 30°$. The percentage elongation produced

$$= \frac{100}{r \sin b}\left[\frac{1}{p}\left\{\frac{(2r+p)^2(t-p)}{8r\sin b} - \frac{3{\cdot}14\,r^2}{360}\cdot b\right\} - \frac{1}{2}\left\{\frac{(2r+p)(t-p)}{4r\sin b} + r\sin\frac{b}{2}\right\}\right],$$

where r is the radius of the roll, t the thickness of the piece before, and p that after the pass. This furnishes a check on the rolling operation by comparison with the percentage elongation given by the metal in the tensile test. The percentage side-spread of the metal as a result of the rolling is:

$$\left(\frac{200}{\omega}\right)\left[\frac{t^2-p^2}{p}\tan\tfrac{1}{2}a\right],$$

where ω is the width of the piece and $a/2$ is

$$\tan\tfrac{1}{2}b\,\tan^{-1}\left[\frac{\left(r+\frac{p}{2}\right)\tan\frac{1}{2}b}{\frac{p}{2}}\right] - \frac{b}{2}$$

The actual side-spread is independent of the width of the piece, depending entirely on this original thickness and the pass. To obtain the max. elongation a strip should be used as wide as possible. F. C. T.

285. *Invariable Pendulums.* **H. Nagaoka.** (Phys. Math. Soc. Japan, Proc. 1. pp. 347–351, Nov.–Dec., 1919.)—This paper is an elaborate comparison of the suitability of various materials available for the construction of invariable pendulums. For this purpose on account of its properties tungsten is strongly recommended. The physical constants of tungsten are given, and it is shown that the pendulum could be entirely constructed of tungsten. The advantage of having every part of the same material is considerable. The points emphasised are the high density, low thermal expansibility, and low magnetic susceptibility, also the great hardness and chemical resistance of tungsten. W. A. R.

286. *Defective Fractures of Tensile Test-pieces of Gun Steel.* **A. Portevin.** (Rev. de Mét. 16. pp. 840–847, Sept.–Oct., 1919.)—Premature fractures showing defective areas in transverse tests of gun-steel are due to the presence of sulphurous inclusions parallel to the direction of forging. These inclusions are revealed by acidulated silver bromide on an elastic base. The local segregations have their origin in the ingot itself, being merely deformed by forging. The advantage of using ingots of small size is shown by the fact that these local segregations are not met with in the external basaltic portion of the ingot. Now if in two ingots of sections s and S the thickness of the basaltic part is e and e' respectively, then on drawing out the ingots to the same final diameter Δ, $e/s = e_1/\Delta$ and $e'/s = e_1'/\Delta$, where e_1 and e_1' are the thicknesses of the original basaltic layer in the billets. If $s < S$ then $e' < e$ and e_1 will be greater than e_1', *i.e.*, from small ingots will be obtained billets with more steel free from these defects. For gun tubes, to eliminate the dangerous area a coefficient of forging should be employed of E^2/e^2, where E is the thickness of the segregated zone in the ingot and e that of the unsegregated external one. Appendices are given in which full instructions are given for the obtaining of sulphur prints from fractures and also a consideration of the effect of quenching upon segregations. F. C. T.

287. *Comparative Endurance of Chrome-Nickel and Nickel Steels.* **H. F. Moore** and **A. G. Gehrig.** (Eng. News-Record, 83. pp. 82–83, July 10, 1919. Paper read before the Am. Soc. for Testing Materials.)—Logarithmic plotting of the normal fibre stress and number of reversals for failure shows that chrome-nickel steel fails earlier than nickel steel under relatively low fibre stresses. These results should not be interpreted to mean that chrome-nickel steel is inferior to nickel steel in resistance to fatigue. Curves for heat-treated steels are of deeper slope than those for annealed steels, indicating a lower ultimate fatigue strength for heat-treated specimens. [This is contrary to general experience.—Abstractor.] Polishing the specimens increases the fatigue resistance, more particularly at low stresses.
F. C. A. H. L.

288. *A Method of Determining Tensions existing in a Circular Cylinder.* **M. Mesnager.** (Comptes Rendus, 169. pp. 1391–1393, Dec. 29, 1919.)—The method of Heyn and Bauer for measuring the internal stresses in cylinders is called in question and the following treatment suggested as an alternative:—If concentric holes are drilled axially in the tube and the increase δd of the external diameter and the increase δl of the length l be measured, then if λ is the longitudinal tension, ρ the radial tension and γ that circumferentially, $\gamma = [\rho_1 r_1^2(1 + r_2^2 r^{-2}) - \rho_2 r_2^2(1 + r_1^2 r^{-2})]\,(r_1^2 - r_2^2)^{-1}$, $\rho = [\rho_1 r_1^2(1 - r_2^2 r^{-2}) - \rho_2 r_2^2(1 - r_1^2 r^{-2})](r_1^2 - r_2^2)^{-1}$; where r_1 and r_2 are the radii of the two coaxial cylinders sustaining at the surface normal tensions of ρ_1 and ρ_2. By detaching a cylinder of radius b from the centre of a cylinder

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of radius a tensions γ' and γ'' disappear from the internal and external surfaces, then $\gamma' = -\rho(a^2 + b^2)(a^2 - b^2)^{-1}$ and $\gamma'' = -2\rho' b^2(a^2 - b^2)^{-1}$. The increase of the external diameter of the tube, δd, then is equal to $-E^{-1}(\gamma'' - \eta\lambda)2a$, E being the Young's modulus and η = Poisson's ratio, while $\delta l = -E^{-1}(\lambda - \eta\gamma'')l$. F. C. T.

289. *Forced Vibrations of a Circular Plate.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 1. pp. 365–377, Nov.–Dec., 1919.)—Mathematical treatment of the problem under a variety of different initial and boundary conditions, also with the plate loaded. E. H. B.

290. *Tension, Impact, and Repeated Impact Tests of Steels.* **T. Matsumura.** (Kyoto Coll. Eng., Mem. 2. pp. 63–69, July, 1918.)—Gives the results of tension tests carried out on a Wicksteed's machine, impact tests on a Charpy machine, and repeated impact tests on a machine of the author's design, of a series of steels varying in carbon content from 0·102 to 0·85 %. In the author's machine, the test-piece rests on supports at the ends and receives blows of a hammer on the central part. Between each blow of the hammer the test-piece turns upside down; the blows are continued and recorded until the specimen breaks.

The tension and impact results are such as would be expected, and the repeated impact tests gave a maximum at 0·25 % carbon. C. O. B.

291. *Visibility of Compressional Waves in Water.* **K. Tsukuda** and **R. Fujii.** (Phys. Math. Soc. Japan, Proc. 1. pp. 358–365, Nov.–Dec., 1919.)—The compressional wave in water from one electric spark between electrodes immersed in the water is rendered visible or photographed by another spark included in the same circuit of capacities and induction coil. This is all after the manner of M. Toepler's arrangement and as used by A. L. Foley and W. H. Souder [Abs. 255 (1909) and 201 (1913)]. Two photographs are reproduced in the paper. E. H. B.

292. *Determinations of very Short Durations.* **C. de Watteville.** (J. de Physique, 9. pp. 91–95, March, 1919.)—Gives descriptions of several arrangements by which a tuning-fork yields a wavy trace of a few wave-lengths and so records the short duration under examination. E. H. B.

293. *The "Slip-curves" of an Amsler Planimeter.* **D. M. Y. Sommerville.** (Phil. Mag. 38. pp. 489–492, Oct., 1919.)—Indicates some of the simple geometrical properties connected with the curves given by A. O. Allen [Abs. 1178 (1914)].

294. *Resolution of a Curve into a Number of Exponential Components.* **J. W. T. Walsh.** (Phys. Soc., Proc. 32. pp. 26–30; Disc., 30, Dec., 1919.)—The paper gives a method for the resolution of a curve of the compound exponential form $B = \sum_{1}^{n} a_1 e^{-\lambda_1 t}$, into its components, the values of a and λ for the n different exponential terms being found from $2n$ values of B equidistant along the axis of t. A method is also given for finding the most probable values of these constants from any number ($> 2n$) of observed values of B taken at irregular intervals of t. AUTHOR.

295. *The Bunsen Aspirating Pump and the Bernouilli Principle.* **W. C. Baker.** (Phys. Rev. 14. pp. 228–233, Sept., 1919.)

296. *Electrodynamic Method for Investigating the Earth's Crust.* **J. Popper-Lynkeus and H. Löwy.** (Phys. Zeits. 20. pp. 488–489, Oct. 1, 1919.)—The present paper gives theory and a discussion of the employment of the capacity and damping method [see Abs. 49 (1920), Abs. 1162 (1912)] in airships. A. W.

297. *New Method of Driving off Poisonous Gases.* **[Mrs.] H[ertha] Ayrton.** (Roy. Soc., Proc. 96., pp. 249–256, Oct. 9, 1919.)—Describes the application of a fan for the above purpose. The physical principle involved is illustrated, and the way in which this was developed to produce the air currents necessary is set forth. L. H. W.

298. *Soap Bubbles of Long Duration.* **J. Dewar.** (Frank. Inst., J. 188. pp. 713–749, Dec., 1919. Paper read before the Roy. Inst.)—An investigation of the properties of soap bubbles is the logical outcome of the experiments on flat liquid films described in the 1916 Friday evening discourse. The flat films described previously were developed in an exhausted atmosphere of nearly pure water-vapour, while soap bubbles are blown up with air in air. Experiments extending over a year have proved that, in order to keep soap bubbles for any length of time, the air must be free from deteriorating gases and suspended solid matters. When bubbles blown with pure air were formed in vessels closed to prevent communication with the outside air, it was soon recognised that when the interior of the vessel had become free from suspended matter by long standing and deposition on the walls the surface of which was coated with glycerine soap solution, the bubbles lasted much longer.

The methods of purification employed for the purpose of obtaining long-lived soap bubbles were (1) simple displacement by purified air; (2) deposition of the solid material by electrical discharge in the space to be utilised.

The author deals with a variety of topics, including the following: (1) Life of bubbles prepared in various ways and containing air; (2) gas transference through black bubbles in hydrogen at ordinary and other pressures; (3) absorption of water by bubbles composed of oleate glycerine solution; (4) variation of composition of the drainage from bubbles.

The paper comprises many tables of observations, and graphs plotted to exhibit the results. E. H. B.

299. *The End Correction in the Determination of Gas Viscosity by the Capillary Tube Method.* **A. F. Benton.** (Phys. Rev. 14. pp. 403–408, Nov., 1919.)—The voluminous data obtained for air from experiments on capillary tubes as flow meters have been used to test the formulæ involving end-corrections, proposed by Brillouin and by Fisher. A measure of the validity of a given formula is obtained by assuming the value of the coefficient of viscosity and comparing the mass of gas transpired per sec., as found experimentally, with the mass computed from the formula in question. The tubes employed in the tests ranged in size from very long lengths, where the end-effect was practically negligible, down to such short lengths that they behaved as orifices.

Under this very exacting test, Fisher's equation for the end-correction is shown to be wholly unsatisfactory and to lead to impossible results. Brillouin's formula, however, reproduces the observed data fairly well. The agreement becomes excellent if the latter formula is slightly modified by the introduction of a constant, similar to the "orifice coefficient," to take account

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of the form of the ends of the tube. Finally a criterion is given for determining the negligibility of the end-correction within any desired limits of accuracy. AUTHOR.

300. *Fluid Motion and Viscosity.* **W. L. Cowley.** (Engineering, 109. pp. 101–102, Jan. 23, 1920.)—The present paper deals with the effect upon fluid motion of local heating due to viscosity and the comparison between experiments carried out in fluids in the two different states, liquid and gaseous. When treating the subject from the standpoint of the dimensional theory, the force R exerted on the body by the flow of liquids is assumed to depend only upon the properties of the fluid ρ, ν, and V (the density, kinematic viscosity, and velocity of sound respectively), and also upon v the velocity, supposed constant, of the general mass of the medium relative to the body, and l the linear scale of the system referred to some drawing. When the velocities, and consequently the pressure variations in the medium are small, the energy dissipated in wave formation becomes negligible, and R may be written equal to $\rho l^2 v^2 f(vl/\nu)$, where the form of the function depends on the shape and orientation of the body to the general flow. By arranging v and l so that vl/v is the same in two distinctly different fluids, the resistances become proportional to the product $\rho v^2 l^2$ if the compressibility is small, and the fact that the fluids exist in two different states does not appear to affect the problem in the slightest degree. To obtain experimental verification a number of tests were carried through both of a qualitative and quantitative nature. The flow of air and of water, when made visible by smoke or small particles, shows a remarkable agreement in the two cases at corresponding values of vl/ν. This seems a remarkable tribute to the above equation, but when the more exact test is made of finding the resistance of a strut first when towed through water, and, secondly, when in a current of air in a wind channel, the results obtained are such that even competent authorities on the subject have been led to doubt the above equation. This discrepancy might be due to two causes: (1) the turbulent nature of the flow in the wind channel, and (2) the possible presence and importance of other factors as yet neglected. The author now examines whether the three physical constants enumerated above fully define the fluid for hydrodynamical purposes. For defining the state he discusses the effects, direct and indirect, of temperature upon fluid motion. The most general form for the resistance is found to be: $R = mN . v^2 l^2 f(s . N, n, Nl^3, u/v)$, where $m =$ molecular mass, $s =$ molecular size, n is a number representing the ratio between the energy of a molecule to the amount of kinematic energy it possesses due to its translational motion, $N =$ number of molecules per unit volume, and $u =$ most probable velocity of the molecule. For practical purposes this equation is written: $R = \rho v^2 l^2 f(vl/\nu, v/V, \phi/k . v/l, S_c/l^3)$ where ϕ is the rate of change of viscosity with temperature, k the specific heat of the fluid at constant pressure, and S_c the critical volume of the fluid. This equation includes the local heating effect and that due to the size of the molecules, which latter is one of the chief factors affecting the state of the fluid. H. H. Ho.

301. *Structure Theory and Cohesion Phenomena.* **W. Voigt.** (Ann. d. Physik, 60. 7. pp. 688–672, Dec. 9, 1919.)—The utilisation of experimental results on the atomic structure of crystals for obtaining theoretical consequences as to the elastic behaviour of these bodies appears to be full of promise. Although the results are few, yet the investigations of Born and

Landé [see Abs. 528 (1919)] give rise to the hope that at least the correct mode of attack has been revealed. The calculation of data for the cubical compressibilities of some regular crystals has been a remarkable success, especially the most recent evaluation of the elasticity constant c_{11}. There now arises the problem whether by the above mode of calculation an explanation may be afforded by means of the hypothesis of electrostatic forces between the atoms as to the laws of cohesion phenomena outside the elastic zone, *i.e.*, of the tenacity, disruption, cleavage, and translation. The difficulty, in the author's opinion, lies in the erratic character of these phenomena. In the case of simple breaking, bending, etc., of some brittle crystals, observation shows a very close proportionality between deformation and force almost up to the tenacity limits, so that the rupture in no wise appears to be anticipated. To this erratic behaviour must be added another which lies in the appearance of definite planes in the crystal. These facts appear difficult to connect with the action of electrostatic forces between the atoms. The recent idea of Landé, that electrons move about the atom in an orbit system corresponding to certain crystallographic symmetries, appears to afford a possible explanation of such erratic behaviour. Proof of this standpoint, however, appears to offer great difficulties, especially as other, more simple problems of stability in the crystal lattice have not yet been solved. Stark has put forward quite different ideas to explain cleavage and flow in crystals. These are discussed very fully in the paper. The author then describes some experimental and theoretical results with respect to quantitative relationships of cohesion phenomena which afford more exact data for the theoretical elucidation of crystal structure. Section 1 deals with crystal flow, by which a permanent deformation is acquired; Section 2 with tenacity; Section 3 with rupture into small pieces, a problem involving a specific surface effect.

The paper is highly mathematical, and the subject is most exhaustively treated. H. H. Ho.

302. *Atomic Structure.* **A. Berthoud.** (Archives des Sciences, 1. pp. 478–496, Nov., 1919. Paper read before the Soc. helvetique des Sciences naturelles, Sept., 1919.)—This is an interesting discussion of recent work on atomic structure from the viewpoint of theoretical chemistry. Emphasis is laid on the fact that positive electricity has never been observed unassociated with at least one atom, and the a-particle is designated as one of the foundation stones of the atomic structure. The classification of the radio-active-elements has been greatly facilitated by the Displacement Law, due mainly to Soddy and Fajans, that *Every transformation in which a-rays are emitted lowers the atomic weight by two units, while the emission of β-rays raises it by one unit.* The isolation of isotopes in weighable quantities has shown their identity in all chemical properties, and also in all physical properties, including their luminous spectra, except radio-activity. And the identity is entirely concerned with the properties of the atom as a whole; *e.g.*, water dissolves, not equal weights, but equal molecular quantities of lead nitrate and radium-C_1 nitrate; their densities and specific volumes are not identical, but their atomic volumes are. It is the atomic number, and not the atomic weight, which determines the properties of an element. Most of these properties are complicated and periodic functions, but, as Moseley has shown, the frequencies of corresponding lines in the high-frequency spectra of different elements are approximately proportional to the squares of the atomic numbers, so that this spectrum determines and is determined by the atomic number.

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Rutherford's observations on the dispersion of α and β particles traversing matter have substantiated van den Broek's view that the atomic number represents the positive charge of the atomic nucleus, when the charge of an electron is taken as the unit. The physical meaning thus given to the atomic number completely accounts for the displacement law. It obviously involves the concentration of the atomic mass almost entirely in the nucleus. The same conclusion had previously been deduced from the observation that the molecular heat of a monatomic gas was 3R/2 instead of 3R, the value to be expected if the molecules had rotational as well as translational energy. The only satisfactory explanation of the absence of rotation is one in terms of energy quanta and on the assumption that the mass of an atom is sensibly concentrated at its centre. But the atom originally conceived by Rutherford would not be a stable system, and the author goes on to consider Bohr's theory as improved by Sommerfeld [Ann. d. Physik, 51. p. 125, 1916], according to whom the electronic orbits may be elliptical as well as circular, affording a complete explanation of the multiform nature of most of the lines observed in the spectra of H and He. For, owing to the variation of the mass of the electron with its speed, every variation in the eccentricity of the orbit will give rise to a slightly different line. The Bohr theory, moreover, accounts for Moseley's law, calculation showing that the α-lines of the K series would arise during the passage of an electron from second to first ring, and the α-lines of the L series during its passage from ring 3 to ring 2. When, too, the complete explanation given by the theory of the Balmer series and of the infra-red and ultra-violet series of lines in the hydrogen spectrum is considered, and its equally brilliant success in the case of the He spectrum, we feel constrained, in spite of the difficulties involved in Bohr's theory, to believe that, whatever modifications may ultimately prove to be necessary, it must to some extent correspond to realities and therefore be leading in the right direction. G. W. DE T.

303. *Einstein's Relativity Theory of Gravitation.* **E. Cunningham.** (Nature, 104. pp. 354–356, Dec. 4; 374–376, Dec. 11; 394–395, Dec. 18, and p. 437, Jan. 1, 1919.)—Sets forth in non-mathematical language the main features of Einstein's theory.

The present author shares with Larmor the view that Einstein's theory does not in reality predict the displacement (deflection of light by gravitation) at all. **J. Larmor.** (Nature, 104. p. 412, Dec. 25, 1919.) L. H. W.

304. *The National Physical Laboratory.* (Engineering, 107. pp. 846–848, June 27; 108. pp. 83–85, July 11; 90–91, July 18 and p. 107, July 25, 1919.)—Contains an illustrated account of the equipment of and the work carried out by the various departments of the Laboratory, as noticed in the course of the annual inspection by the General Board. L. H. W.

305. *Periodogram Analysis of Greenwich Temperature Records.* **D. Brunt.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 323–335; Disc., 336–338, Oct., 1919.)—Monthly mean temperatures for the 50 years from 1841 to 1890 are corrected for annual variation, and then a Fourier series is evaluated up to the first 100 terms in order to locate such periodicities as may exist. For the one-year and shorter periods the following terms are obtained: $t = 49{\cdot}5^\circ - 12{\cdot}2^\circ \cos(\theta - 7^\circ) + 1{\cdot}3^\circ . \cos 2(\theta - 16^\circ) + 0{\cdot}33 . \cos 3(\theta - 9^\circ)$. The amplitudes of the remaining terms are less than 0·1 deg. F. For the longer

periods periodicities having amplitudes of 0·4 deg. F. and upwards (greatest 0·6 deg.) are found with the following periods: 5 years, 8·955 years, 812, 691, 594, 228, 154, 152, and 182 days. There are also two longer periods of about 8 and 6 years respectively. The 5-year periodicity appears to exist throughout the whole of the 50 years first investigated, and also through the subsequent 15 years ending 1905. Other periods such as that of 594 days exist only for a part of the interval, after which they suddenly die away. The general result of the investigation goes to show that except for the annual variation and its sub-multiples, periods in the astronomical sense do not exist in these temperature records. The effect of correcting the residual temperature (that is, temperature corrected for annual variation), for the effects of the chief periodicities found is to reduce the standard deviation from 2·8 deg. to 2·6 deg. F.; so that only a small part of the variation of the monthly mean temperature is accounted for by the existence of these periods. In the *discussion*, **J. I. Craig** said that he had found a sudden origin and cessation of periodicities in dealing with Nile Flood records over a series of 800 years. **C. E. P. Brooks** had found periods of 38 and 26 months in West African rainfall, corresponding to two of Brunt's periods. **F. J. W. Whipple** agreed with the author in thinking that there was little reason to suppose that the periods of over one year were significant. **H. H. Turner** found confirmation of his periods or "chapters" in Brunt's work. J. S. Di.

306. *Note on Tornadoes.* **J. Logie.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 317–320; Disc., 321–322, Oct., 1919.)—The question as to whether the decreased pressure in the centre of a tornado can be accounted for by the relative warmth of the central column of air such as might be produced solely by condensation, is investigated for (*a*) a mild tornado, depression of the barometer = 50 mb., and (*b*) a severe tornado, depression = 250 mb. Heights of 5, 10, and 15 km. from the ground to the top of the whirl are considered. Assuming that at the top of the column pressure is the same inside and outside of the tornado, it is found that the mean temperature difference between core and outside air must be 5 deg. C. for a mild tornado of 15 km. height, but 220 deg. C. for a severe one of 5 km. height. These represent the extreme cases. This difference of temperature has on the usual hypothesis to be produced by the liberation of latent heat in the moist rising air of the core. It is demonstrated that this cause might under exceptionally favourable conditions of the surrounding atmosphere be adequate in the case of a mild tornado, but it is entirely inadequate for a severe one. The failure of the convection theory to produce the necessary warmth of core being demonstrated, the author tentatively puts forward the suggestion that the heat produced by lightning might prove an adequate source. The air in the core being subject to little mixing, would become ionised by the first flashes and form a conducting path for future discharges. Thus all the heating would be localised. In the *discussion*, **E. Gold**, assuming the area of the core to be 1 sq. km., found that the heat produced by lightning flashes would be insufficient to produce the required effect. The **Author**, in reply, suggested an area of 0·002 sq. km. only, which makes the calculated rise of temperature much larger. J. S. Di.

307. *Meteorological Conditions affecting Aviation in Mesopotamia.* **C. W. B. Normand.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 368–379, Oct., 1919.)—There is seldom a day in July or August in Baghdad when temperature does not reach 100° F. Absolute extremes at the same station over 25 years are 122·8° (July) and 18·6° (Dec.), a range of 104 deg. F. The great nocturnal radiation leads to large temperature inversions in the early morning in the first 1–2000 ft. above the ground. On Dec. 3rd, 1917, at 7 a.m. temperature was 48° F. on the surface, but shortly after was found to be 61° F. at 1000 ft. height. The main air movement is parallel to the river valley, the dominant wind direction being from N.W. Winds which have an easterly component on the surface show a marked tendency to become westerly above, so that aeroplanes flying to India will nearly always experience a following wind above 6000 ft. From April till the winter rains commence, the ground becomes more and more parched, and with a marked diurnal range of wind speed, dust storms are common in the day-time. An aviator who commences a flight under favourable conditions in the early morning may descend in a severe dust storm. The number of raindays at Baghdad is 27 per annum, almost all of which fall between Nov. and April. The number increases with proximity to the hills. Thunderstorms in March and April offer danger to aeroplanes, being accompanied at times by heavy hail. The climate should afford more flying days than Britain, though it is less ideal than Egypt. J. S. Dr.

308. *The Climate of North-west Russia.* (Meteorolog. Office, Professional Notes No. 7 [27 pp.], 1919.)—The area embraced extends north to south from the Arctic Ocean to Petrograd and west to east from the Swedish frontier to 45° E. longitude. Climatic data of temperature, humidity, cloud, fog, precipitation, and wind are tabulated for 7 stations. A discussion of the data draws attention to the salient points and gives additional information. The comparative warmth of the coast of the Arctic Ocean makes navigation to Murmansk possible throughout the year. Thus Jan. temperature at Alexandrovsk, near the mouth of the Kola river (69° N.) is little lower than that at Petrograd (60° N.). At Archangel the highest maximum in July averages 80° F., while the lowest minimum in the same month averages 39°, a range of 41 deg. In winter the corresponding range is larger, 58 deg. F. in Jan. The principal events of the meteorological year, the freezing and thawing of the rivers, occur shortly after the passages of mean air temperature through 32° F. The mean date of the freezing of the Dvina at Archangel is Nov. 5th, of thawing May 18th. The date of freezing is considerably the more variable from year to year. Navigation to Archangel through the White Sea is usually open about May 21st. Snowfalls of more than a few inches in the day are rare, and the cumulative depth does not exceed about 3 ft. at the end of winter. On the great plains of Russia gales are infrequent, but on parts of the Arctic coast they are almost continuous for long periods in winter. Diagrams are given which show clearly the incidence of cloud, rain, and fog with different winds. Mean upper-air temperatures are set out for Petrograd and Kiruna in Swedish Lapland. J. S. Dr.

309. *Rigidity of the Earth.* **A. A. Michelson** and **H. G. Gale.** (Astrophys. J. 50. pp. 330–345, Dec., 1919.)—In 1914 an account was published of a preliminary experiment to determine the rigidity of the earth [see Abs. 1038 (1914)]. At that time it was announced that the experiment would be repeated, using an interference method [see Abs. 48 (1920)]. The later experiments are now described in detail. Interferometers are used in place of the micrometers and pointers, their arrangement being shown in a diagram, and devices for recording the fringes are fully given. The sources of light used were commercial alternating-current Cooper Hewitt mercury lamps, which proved very reliable and satisfactory. By using as filters thin films of a saturated solution of æsculin in water, all wave-lengths from the arc shorter than λ4358 were absorbed, and the positive film used was not sensitive to the longer wave-lengths. The fringes, estimated to tenths, were counted as they moved up and down, and the numbers recorded for each hour. The difference in the motion at the two ends of each pipe gave the numbers for plotting the observed tides. Calculated and observed curves are given. Various disturbances are discussed in detail, and 7 tables of results are given. The rigidity of the earth in the N.–S. and E.–W. directions is the same. That the viscous yielding of the earth is small is indicated by the small difference in phase between the observed and computed tides. The two solar tides appear to agree excellently in phase displacement with the E.–W. semi-diurnal tide, and that for the N.–S. semi-diurnal, and also probably the E.–W. diurnal lunar tides; the phase displacement is definitely smaller. For lack of a better method of finding the means of the N.–S. and E.–W. phase displacement, each was averaged by weighing them in proportion to the amplitudes of the tides. This gives a displacement in phase of the water tides in the N.–S. direction of + 2°41′, and in the E.–W. direction of + 4°34′. Although it seems certain that the difference in phase is slightly larger in the E.–W. than in the N.–S. direction, a mean displacement of + 4°, is probably correct to within 1°.

H. H. Ho.

310. *Atmospheric Pressure and Earthquakes.* **T. Terada** and **S. Masuzawa.** (Phys. Math. Soc. Japan, Proc. 1. pp. 343–347, Nov.–Dec., 1919.)—The importance of the barometric gradient as a secondary cause of earthquakes has been established. The effects of the distribution of the barometric gradient are here statistically examined. The Pacific submarine earthquake zone was chosen as the region for examination. The earthquakes appear to be frequent when the deviation of the gradient is directed to both sides of a certain line of demarcation running at right angles to the central axis of the land. The type of surface loading revealed by this investigation, if applied simultaneously, will be favourable to produce a fracture along the line mentioned.

W. A. R.

311. *Tidal Friction.* **G. I. Taylor.** (Roy. Soc., Phil. Trans. 220. pp. 1–33, Nov. 29, 1919.)—The rate of dissipation of energy at Spring Tides is calculated from the ordinary theory of skin friction of fluids against solids. The results range from 1040 to 1300 ergs per cm.^{2} per sec. The least of these is 150 times as great as Street's estimate of 7 ergs per sec. Street assumed that the energy was dissipated by the viscous drag of water layers moving parallel to the sea-floor, but such lamellar motion of tidal currents is opposed to ordinary observation. To check this estimate the rate of energy supply to the Irish Sea is calculated from the tidal rise and fall, the current strength and the phase difference over two sections taken across the north and south channels. The rate of dissipation by this method is found to be 1530 ergs per cm.^{2} per sec.—in agreement with the previous result. Three-quarters of the energy of the incoming tidal wave is absorbed, and this absorption explains most of the chief characteristics of the Irish Sea.

W. A. R.

312. *New Subterranean Clock-room at Argentine National Observatory.* **M. L. Zimmer.** (Astron. J. 32. pp. 137–138, Jan. 5, 1920.)—In order to secure uniformity of temperature as an alternative to perfect compensation

for changes of temperature, advantage is taken of the fact that temperature changes do not take place below a certain depth (10 m. at Cordoba). The electric control previously employed was satisfactory in its performance, but was at the mercy of arbitrary failures due to cutting off of the local current.

Arrangements are made to wind the clocks in the chamber constructed at the bottom of the ten-metre bore, of two metres' diameter, and also to record the time indications without disturbing the conditions by going down to the chamber. The only unavoidable interference contemplated is from earthquakes, but for any meridian observatory the plan is strongly recommended.
W. W. B.

313. *Solutions in the General Problem of Three Bodies.* **E. Strömgren.** (Roy. Astron. Soc., M.N. 80. pp. 12–22, Nov., 1919.)—In this paper the author gives a result which has been obtained by him and his co-workers during the work on the non-restricted problem, where the masses and the distances are both of the same order of magnitude. L. H. W.

314. *Physical Aspect of Einstein's Prediction.* **H. F. Newall.** (Roy. Astron. Soc., M.N. 80. pp. 22–25, Nov., 1919.)—The author is indisposed straightway to accept the view that the whole of the deflection measured on the recent eclipse photographs is due to the Einstein-effect, leaving nothing for optical refraction or similar causes. Admitting that the simple gravitational field of the sun can only account for an atmosphere of small height, he considers that the extensions of the corona, prominences, etc., demand additional forces, such as those provided by radiation-pressure, and these, producing a field of much greater extent radially from the sun, he thinks may cause much more refraction than is generally expected. He had this point in view for the last eclipse and provided Eddington with means for testing whether the spectra of ϵ_1 and ϵ_2 Tauri showed any absorption effect during the eclipse. If they had done so he would regard it as evidence not only of absorptive power but of refractive power in the sun's surroundings at that distance. Eddington was unable to fit the scheme into his programme, and in any case, clouds interfered, which would have rendered the test valueless at that station. The author hopes to try it himself in Australia in 1922. He is prepared to find some effect which may well affect Mercury without reaching so far as Venus; and he considers the argument from comets as of little weight, since there is no evidence of symmetry about perihelion in most cases, and in that of the comet of 1843, not only were all the observations after perihelion, but the computed periods vary from about 6 years to more than 500, so that clearly the elements are uncertain. W. W. B.

315. *Diffusing Action of Solar Gases, as cause of apparently Sharp Boundary.* **C. G. Abbot.** (Astrophys. J. 50. pp. 295–307, Nov., 1919.)—Owing to molecular scattering and true absorption by its gases, radiation can only travel perhaps 7000 km. in the outer layers just beneath the chromosphere. Outside of the chromosphere the gaseous density is so small that the brightness is not comparable with that of our atmosphere near the sun. Thus the interior (depth greater than 7000 km.) contributes nothing but maintenance of heat, and the sun radiates like a hollow shell, thicker for longer waves than for shorter ones, and also thicker in the centre, when the 7000 km. can be measured normal to the surface. At the limb the 7000 km. really means about 700 km. in thickness, or less than 1″ of arc, a quantity too small to be distinguishable from bad seeing of the limb. If the increase

of density within the surface is as rapid as supposed by Emden and Schwarzschild, the rapid increase of brightness at the limb is well accounted for. W. W. B.

316. *Solar Prominence,* 1919 *May* 29. **J. Evershed.** (Roy. Astron. Soc., M.N. 80. pp. 8–11, Nov., 1919.)—Six photographs are given of the stages of this prominence, three on the disc and three at the limb with description of measurements of height and extent at different dates. It appeared to rotate with the speed of the spots and reversing layer, and not with the higher speed found for the chromosphere. The author thinks it may mark the boundary of a region of sun-spot disturbance, and to be probably another manifestation of the disturbance that causes sun-spots and flocculi. W. W. B.

317. *Corona and Prominences at Eclipse of* 1919, *May* 29. **A. C. D. Crommelin** and **C. R. Davidson.** (Roy. Astron. Soc., M.N. 80. p. 12, Nov., 1919.)—The corona is described as being partly of minimum type, and a very satisfactory photograph was obtained accidentally, as thin cloud interfered with the original purpose of the series of exposures. A description of the great prominence shows that it altered markedly in appearance during the 2¼ hours that elapsed between the time of eclipse at Sobral (Brazil) and at Principe (West Africa). W. W. B.

318. *Atmospheric Haze and a Suspected Variation of the Solar Rotation in* 1915. **H. H. Plaskett.** (Roy. Astron. Soc. Canada, J. 13. pp. 391–402, Nov., 1919.)—Variation in the solar rotation, alleged by the author in 1915, has been denied by R. E. De Lury [see Abs. 25 (1919)], who considers that blended spectra due to haze is the cause of the appearance described. The author is now defending his position, by attacking his opponents' premises, and showing that: (1) Correlation between the brightness record and solar rotation velocity is too small to be significant. (2) Large velocities for strong lines do not prove the presence of haze. (3) The rotation observations were taken under conditions precluding the presence of more than 5 % haze, thus the velocity determinations could not have been affected more than 2 %. The author considers that this disposes of the "haze" hypothesis, leaving the variation of rotation velocity to be explained in some other way. He suggests that either they are evidence of an actual variation in velocity in the equatorial belt of the sun, an analogy being drawn with Abbot's observations of variable "Solar constant" in the same year (1915), or (and this he thinks more likely) the effects were local, and due to minor disturbances in the outer layers of the solar envelope. W. W. B.

319. *Eclipse Photographs.* (Observatory, No. 42. p. 405, Nov., 1919.)—The main purpose of the eclipse expeditions to Sobral and Principe was to photograph stars near the eclipsed sun. Clouds interfered to some extent and enabled a good picture of the corona to be obtained on a plate which failed to show the stars. It was taken at Sobral with a 4-in. lens of 19 ft. focus. A second reproduction shows the large prominence at the eastern limb both at Sobral and Principe. W. W. B.

320. *Lunar Photography with the* 100-*in. Reflector.* (Pop. Astron. and Astr. Soc. Pacific, Publ. Dec., 1919. Nature, 104. p. 511, Jan. 15, 1920. Abstract.)—The two American publications contain reproductions of fine photographs taken at Mt. Wilson with the new reflector, to be known as the Hooker telescope. The equivalent focal length is 134 ft., so that the large

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scale permits very fine detail to be shown. Hale states that the motions of faint stars in the heart of globular clusters and in the star-clouds of the Milky Way can be measured. Nebulium has been found in R. Aquarii and luminous clouds of calcium vapour are found surrounding the star in Hind's variable nebula in Taurus. It is also possible to study the spectra of the faint companions of close double stars. So that not only does the instrument perform all that was hoped of it, but also the seeing conditions at Mt. Wilson are good enough for such refined purposes. W. W. B.

321. *Large-scale Experiments Imitating Lunar Craters.* **H. E. Ives.** (Astrophys. J. 50. pp. 245–250, Nov., 1919.)—Photographs taken from the air of the effect of bomb-dropping on a fairly large scale afford very plausible evidence that the lunar craters are more likely to have been formed by impact than by volcanic action. The author meets some of the supposed difficulties which have been brought forward in opposition to the bombardment theory: *e.g.*, the absence of similar effects on the earth; the prevalence of the circular shape, and so on, and he replies to the objection that meteors are not explosive bombs, by the argument that the enormous heat generated by a direct collision with the moon's surface, far greater than that which causes fire-balls to explode in our atmosphere without reaching the earth's surface, is more than sufficient to produce all the explosive effect necessary. W. W. B.

322. *Problems of Sidereal Astronomy.* **H. N. Russell.** (Nat. Acad. Sci., Proc. 5. pp. 391–416, Oct., 1919.)—The National Research Council is arranging for a series of research surveys, of which this first one deals with astronomy. The tendency of modern progress is not so much to accumulate facts by observation, in order to provide fields for theoretical investigation, as to concentrate attention on branches where the lack of such data is obvious, and make observations with these special purposes in view, as well as trying to avoid unnecessary duplication of work. The present report deals fully with the present state of investigation in various fields of sidereal astronomy, laying stress on points where progress is specially desirable. Under I. *Individual Stars*, for instance, the author mentions specially (*a*) evolution of binary systems, (*b*) causes and mechanism of variation in brightness, and (*c*) the source of the energy radiated into space. Similarly with II. *The Galactic System* and III. *Clusters and Nebulæ.* In *Spectroscopy* he notes the diminishing number of lines not identified, the way in which all spectra fit into the same sequence, and the probability that all variations depend on the effective surface temperature. He hopes means will be devised for photographing spectra of stars fainter than the tenth magnitude, and that more attention will be paid to the very red stars. Colour index and colour changes, especially of Cepheid variables, are important lines of investigation. Parallax determinations need clearing of systematic errors to improve their accuracy, and the determination of absolute magnitudes will follow. Proper motions, radial velocities, solar motion in relation to spectral type groups, mass, density and internal constitution of stars, clusters and nebulæ, come under review in turn, and finally the author treats of theoretical investigations, including the work of Eddington, Jeans, Schwartzschild, and Nicholson. W. W. B.

323. *Theory of Jupiter's Satellites.* II. *The Variations.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 22. 3. pp. 236–241, 1919.)—This further stage [see Abs. 57 (1920)] is still restricted to the non-periodic part of the perturbative function, and does not yet include second-order terms of the variation from the intermediate orbit, also the inclinations of the orbit planes of the satellites to that of Jupiter's equator is not taken into account, but the author claims that his new method is an advance on Souillart's. As before, the details of the computations are not given, being reserved for the Leiden Annals. W. W. B.

324. *Clouds on Venus?* **J. Evershed.** (Roy. Astron. Soc., M.N. 80. pp. 7–8, Nov., 1919.)—The author finds a much longer exposure is required to photograph the spectrum of Venus than that of a bright cumulus cloud. He infers that Venus may not be covered with a very cloudy atmosphere, as supposed by H. N. Russell and others, but that possibly the prevalence of dust here may prevent the details of the surface of the planet from being visible on the earth. W. W. B.

325. *Short-period Variable Y Lacertæ, with Remarks on the Phase-Relation.* **C. Martin** and **H. C. Plummer.** (Roy. Astron. Soc., M.N. 80. pp. 33–41, Nov., 1919.) — Measures of Dunsink photographs over a period of about six years provide a correction which reduces Ichinohe's period of 4·8254 days to 4·8285 days. Details are given of the exposures, mostly of 30 minutes, but some shorter and a few as long as 1 hour. A suggested light-curve is given with two pauses on a slow down-grade and a quick up-grade. In the discussion which follows on the phase-relation the authors seem to think that $\phi_3 =$ constant is pretty well as good a representation of the class as Phillips' $\phi_3 - 0·6\ \phi_2 =$ const. and certain cluster variables in ω Centauri, and M 3, M 5, and M 15 are tabulated in support of this. The sub-class *c* suggested by Bailey is shown to agree as to the mean value though having a large range in individual values. A modification of Phillips' formula is tentatively suggested as likely to simplify the physical interpretation. W. W. B.

326. *Photographic Effective Wave-lengths of Nebulæ and Clusters.* **K. Lundmark** and **B. Lindblad.** (Astrophys. J. 50. pp. 376–390, Dec., 1919.)—This is the second paper on the subject [see Abs. 148 (1918)]. 44 objects have been employed in this investigation, and the authors conclude that different kinds of objects correspond to certain characteristic intervals of wave-length. Thus they obtain mean wave-lengths 418 $\mu\mu$ for planetary nebulæ, 419 $\mu\mu$ for globular clusters, and 429 $\mu\mu$ for spiral nebulæ. This may be an aid to classifying doubtful objects. They compute from the effective wave-lengths spectral types and colour indices, but the principal conclusion is that the classifying of faint nebulæ into planetary and spiral divisions can be rigorously effected by their process. W. W. B.

327. *Long-period Variable W Cygni.* **H. H. Turner** and **M. A. Blagg.** (Roy. Astron. Soc., M.N. 80. pp. 41–64, Nov., 1919.)—This star was noted as interesting in a previous paper [Abs. 507 (1918)]. The authors have since been provided with numerous observations by members of the Variable Star Section of the British Astronomical Association, and these have formed the basis of an exhaustive analysis. They find systematic differences between the six observers. Clearing these there are two distinct periodicities, one of 129·6 days and the other of 243 days (ratio 8 to 15). There remain abrupt changes of phase; besides a possible variation in the L.C.M. of the two

periods, 1944 days. The authors give a diagrammatic ephemeris for a complete 1944-day period. They suggest evidence that the variation is in magnitude and not in brightness, and that a possible explanation of the dual period is that the star is changing over from Group II to Group I of Phillips' classification. Observations in Harvard Annals, previously unnoticed by the authors, furnish a useful check on the analysis and show previous jumps in the phase.
W. W. B.

328. *Photographic Evidence of the Formation of Stars from Nebulæ.* **A. L. Cortie.** (Observatory, 42. pp. 398–401, Nov., 1919.)—This is a summary of a lecture delivered to the Royal Photographic Society. After sketching the history of the application of photography to celestial objects, he dwells on the fact that stars involved in spiral nebulæ are always arranged on the convolutions of the spirals, proving a physical connection. The characteristic appearance of spiral nebulæ is a central condensation and two spiral convolutions starting from opposite points of the central nucleus, and having condensations like stars, at intervals along the arms. As Nature works usually from the simple to the complex, this points rather to the evolution of star from nebula, than *vice versa*. An appeal to spectroscopic evidence confirms this order of evolution, and the successive classes indicated are: Green nebulæ containing H, He, Nb. Stars with H and He prominent. Stars with H only prominent. Then come stars containing Ca, and more and more metals. Yellow stars including the sun. Then fluted spectra, indicating the presence of compounds due to lowering of temperature, and so on down to red stars.

The author claims no definite proof of any stage, but appeals to the consistency of the theory, which he thinks provides an accumulation of evidence all pointing the same way: to the evolution of stars from nebulæ.
W. W. B.

329. *Progressive Changes of Stellar Wave-lengths with Change of Type.* **S. Albrecht.** (Astrophys. J. 50. pp. 277–289, Nov., 1919.)—Preliminary results by the author have been criticised by Voûte and by Baxandall [see Abs. 755 and 1286 (1918)], neither of whom appear to have seen more recent revised but still preliminary results published in the Cordoba Observatory *Boletin.* The author here gives a more satisfactory tabular comparison. He applies systematic corrections to Voûte's wave-lengths in order to facilitate comparison, and bearing in mind that an appreciable range of accidental differences is to be expected, comes to the conclusion that the two sets are not contradictory and that Voûte's figures also confirm the idea of a progressive variation of wave-length with type. W. W. B.

330. *Radial Velocities of 185 Stars observed at the Cape.* **J. Lunt.** (Astrophys. J. 50. pp. 161–178, Oct., 1919.)—In continuation of a paper [see Abs. 267 (1919)] dealing with 119 brighter stars, this present one is concerned with stars between 8·7 and 4·6 magnitudes with a wider slit, those suspected of variable velocity being tabulated separately, as before. This division is rendered rather less definite by the more diffused character of the spectra, due to the wider slit. A comparison is made with results for the same stars obtained at Lick Observatory, and by the D. O. Mills Expedition to Chile. 68 of the stars are in the list for variable velocity, 39 already known, and the rest either obviously variable or else suspected. 28 stars are rejected of types A to F 5, on account of the diffuse character or small number of lines shown by the dispersion employed. W. W. B.

331. *Explanation of Light-Curve and Pulsation of Cepheids: Analogy with Primitive Solar Nucleus.* **E. Belot.** (Comptes Rendus, 169. pp. 1083–1086, Dec. 8, 1919.)—The author accepts Shapley's theory that Cepheid variation is due to pulsation, or mass-vibration, in preference to that of eclipsing variables, and examines Moulton's suggestion of alternate polar and equatorial inflation at constant volume of a gaseous sphere, to see whether it will account for the increase of brightness being more rapid than the decrease; the maxima occurring whenever the mass is spherical, *i.e.*, twice in each complete pulsation (prolate to oblate and back.) He considers the cases of polar and equatorial presentment, the latter being, he thinks, usual with Cepheids which probably have their rotation axis perpendicular to the plane of the galaxy. He computes the original diameter of the solar nucleus to be of the same order as those of the Cepheids, and finds 41 days as the period of a pulsation, and 14 of these by his planetary theory, are required after the emission of Neptune's anchor-ring. This 1½ years is in agreement with an independent determination of the duration of the passage through the nebula, and also with the fading of a nova to the Wolf-Rayet type stage. He concludes that the Cepheids also owe their pulsation to a collision with a nebula, just as he thinks the spiral arms of the Milky Way do. [See Abs. 210 (1920).] W. W. B.

332. *Brightness of Betelgeuse.* **D. E. Packer.** (Observatory, 42. pp. 405–406, Nov., 1919.)—The author noted on several occasions in September that this star, *α* Orionis, was undergoing one of its periodical increases in brightness. He claims to have seen it brighter than Procyon or Rigel. Greenwich observers in October found it on the whole brighter than Procyon but not so bright as Rigel; but only one of three confirms the author's statement that the colour was redder than usual. W. W. B.

333. *Brightness of the Night-Sky and Total Light of Stars.* **P. J. van Rhijn.** (Mt. Wilson Observat. Contrib. No. 173. Astrophys. J. 50. pp. 356–375, Dec., 1919.)—Observations of the brightness of the sky were made at Mt. Wilson in the summer and autumn of 1918, the main points in view being the total amount of starlight per square degree for each galactic latitude, and the distribution over the sphere of the sky illumination not due to the stars. The observations were in two stages, every area being compared with an area at the North Pole and that standard area with a star of known magnitude. This latter was determined several times each night and the areas were taken first on a circle parallel to the horizon and then on a circle perpendicular to the horizon. The author, in contrast to a previous result at Groningen, found that the "earthlight" varied with the azimuth, and that it was a zodiacal effect. The brightness of the area at the North Pole was found to fluctuate sometimes 20 % during the same night, but nothing systematic was discovered. The zodiacal light appeared all over the sky, and was very troublesome. Seeliger's theory is not contradicted, but the matter is rather indefinite. The earthlight when corrected for zodiacal glow depends on the zenith distance, and there is evidence of a perpetual aurora.

From the observations taken more than 40° from the galaxy, the author finds the observed brightness, corrected for starlight, excess of zodiacal light, and scattered earthlight to be practically constant above an altitude of 20°, and on this assumption the galactic regions were tabulated also. The resulting total starlight per square degree, in terms of a unit = star of magnitude 1·00 on Harvard visual scale, varies from 0·080 in the galactic plane to 0·010 at the galactic pole, and a comparison is given with previous results. The total light of all the stars is equivalent to 1440 stars of unit magnitude. W. W. B.

334. *Existence of External Galaxies.* **H. Shapley.** (Astron. Soc. of the Pacific Publ., Oct., 1919. Roy. Astron. Soc. Canada, J. 13. pp. 438–446, Dec., 1919.)—It is now regarded as certain that of the various classes of objects suggested from time to time as possible external universes, the large star clouds of the Milky Way, the Magellanic clouds, and globular clusters are definitely discredited. Various peculiar nebulæ and nebulous stars provide a fourth class of which little is known, but are probably also connected with the galaxy. The present paper discusses the case of the spiral nebulæ which have not yet been generally accepted as belonging to the same system. Arguments for and against the hypothesis that they are "island universes" are set out fully, and the author is mainly concerned with a critical examination of those commonly regarded as most favourable to the "external" hypothesis. The avoidance of the Milky Way region by spirals he regards as quite possibly evidence of a connection with the main galaxy. To the suggestion that the avoidance is not real but due to obscuring matter, he replies that globular clusters do not confirm this hypothesis, though it may account for their paucity in low galactic latitudes. To arguments from the high radial velocities of spirals, he replies that most of these are no greater than the measured velocities of globular clusters and other bodies which clearly do belong to the galactic system. He does not accept the analogy between stars and secondary nuclei in spirals, which latter, he says, are easily recognisable as much softer than stellar images. He deals more confidently with further tests. The recent estimate of the diameter of the galactic system has run up from 10,000 to 300,000 light-years, an increase which demands that if a bright spiral of 10′ diameter is really comparable with the galactic system, it must be at a distance exceeding 100 million light-years. Moreover, the same hypothesis, taken in conjunction with careful spectroscopic measures of rotation and translation, demands rotational velocities greater than the velocity of light, and also the absolute luminosity of a nova of the 16th apparent magnitude would have to be of the order of —16, or more than 10,000 times brighter than any known star.

He concludes that though there may be other galaxies somewhere in space, we may feel confident that they are not found among the most distant sidereal groups now recognised. W. W. B.

335. *Probable Motions in Spiral Nebula M 51 (Canes Venatici).* **W. J. A. Schouten.** (Observatory, 42. pp. 441–444, Dec., 1919.)—On Potsdam plates taken in 1891 and 1915 the author measured the tangential and normal components of the motion of eleven knots on the spiral nebula M 51. By rejecting two outstanding ones he obtains a small rotation, in agreement with a previous determination of Kostinsky, but much smaller than that found by van Maanen for M 101. He is unable to confirm a difference between the rotation of the inner and outer spiral, claimed by Kostinsky. W. W. B.

336. *Stationary D-lines of Sodium in Spectroscopic Binaries β Scorpii and δ Orionis.* **M. L. Heger.** (Lick Observat. Bull. 10. No. 326. pp. 59–68, 1919.)—Some early type spectroscopic binaries show H and K lines of calcium stationary, pointing to the possible interposition of a calcium cloud in the line of sight. Two of these stars have been examined by the author to test a corresponding property of the sodium lines, and he finds the D lines sharp and narrow, unlike the ordinary stellar lines, and practically stationary, the mean velocity being the same as that of the H and K lines and of the solar motion. Presumably a relation exists between the calcium and sodium, which have probably a common cause. The velocity of these early type stars is so small that it is very difficult to differentiate between an agreement with the solar motion and with that of the star, and the very small motion found in the D lines may be an oscillation in the period of the binary, in which case the cloud of sodium vapour would not be independent.

W. W. B.

337. *Barnard's Proper-Motion Star.* (Nature, 104. p. 420, Dec. 25, 1919.)—This note on a paper by K. Graff in Astr. Nachr. (4989 and 5007) produces evidence that this star was certainly observed at Bonn on May 30, 1854, as well as at Munich in 1842. On July 24, 1854, the B. D. observation is probably of this and a close neighbouring star seen as one object. Graff thinks the diameter of the star is half that of Jupiter or $\frac{1}{20}$ that of the sun, but this is much below Eddington's limit for possible sun-like condition ($\frac{1}{8}$ sun's diameter). A more probable assumption is that the density is eight times that of the sun and the diameter a quarter that of the sun. W. W. B.

338. *Great Eruptive Prominences of May 29 and July 15, 1919.* E. Pettit. (Astrophys. J. 50. pp. 206–219, Oct., 1919.)—A complete history of these prominences was obtained with the Rumford spectroheliograph attached to the great 40-in. Yerkes refractor, with which it is possible to make successive exposures of the entire limb at less than 10-minute intervals, or with two observers at about 8-minute intervals, the solar image being 7 in. in diameter. Six reproductions are given of the May prominence and three of the July one. The vertical velocity of the prominences was determined, and appeared to increase in three successive jumps for the May prominence and with one such jump for the July one. In a series of 7800 spectroheliograph plates extending back to 1908 only two eruptions yielding similar data can be found, and these both show one jump in the rate of increase of velocity. Other observations will be searched for.

The general conclusions of the author as to the motion of the eruptive prominences are: (1) Before the ascent the under side of the prominence is compressed as if a force were pressing on it over a large area; (2) the velocity is at all times uniform, but suddenly increases at intervals, as if acted upon by an impulse of very short duration. This second rule holds good not only for the two previous cases found in the Yerkes series, but also for 12 other eruptive prominences observed either visually or photographically which have been examined since the paper was prepared. The cases cited differed in form and other characteristics, hence the principles seem to apply generally to eruptive prominences.

Knots of matter in the May prominence were moving in an elliptic arc into the spot with velocities increasing on approach to the spot. W. W. B.

LIGHT.

339. *The Polar, Multi-exposure High-speed Camera.* **J. W. Legg.** (Elect. J. 16. pp. 509–512, Dec., 1919.)—The most common form of motion-picture camera takes pictures at the rate of about 16 per sec. Special cameras have been in use which take pictures of moving objects at several times that rate. However, to make a detailed study of electric arc phenomena, this rate of exposure must be increased one or two hundred times. This is especially necessary in order to obtain valuable data on the phenomena encountered in circuit-breaker arcs and in commutator flashes. The light in arc photography is so extremely intense that it is possible to use a small, inexpensive lens and still obtain a good arc picture when making a very short exposure. For high-speed work it is desirable to replace intermittent or reciprocating action by simple rotary motion. A high-speed, multi-exposure camera has been developed with the intermittent shutter movement of other cameras replaced by simple rotary motion. All parts of the camera remain stationary except the very light aluminium-disc shutter. The lenses are quite inexpensive, and are arranged staggered, in circles, with the shutter shaft as centre. The shutter consists of a thin Al disc with a radial slot, which exposes the lenses in sequence. The sides of the slot are cut along radii of the disc so as to give equal exposure to the lenses near and far from the centre of rotation. By staggering the lenses more exposures can be obtained on the same plate and a greater number of exposures per sec. can be obtained with the same shutter speed. A slot farther from the centre of the shutter, and diametrically opposite the main slot, uncovers lenses arranged in an outer circle so as to give simultaneous exposures for stereoscopic views. The stereoscopic lenses are spaced much farther apart than the human eyes, so, when the pictures are properly reversed and mounted in a stereoscope, the object photographed appears nearer to the observer than it actually was from the camera.

There are 22 different lenses in the high-speed camera shown in the text, giving 16 consecutive exposures, on one 8 by 10-in. plate; 6 of the exposures have stereoscopic mates. This camera has been used to take pictures of arc phenomena at more than 100 times the rate normally used in motion-picture work. At a shutter speed of 10,000 revs. per min. it will take 16 successive exposures in 0·006 sec. The stereoscopic effect increases the value of the arc photographs greatly, as it shows plainly the third dimension. In some cases, for instance, a single picture seems to show a somewhat flattened crescent arc, while the stereoscopic views show two crescent arcs in different planes. The stereoscopic view shows very plainly when the arc bends towards or away from the camera. Another case of the value of the stereoscopic view was demonstrated in a picture of a flash-over on a rotary converter where the single exposure seemed to indicate that an arc struck to the end frame; the stereoscopic view showed that the arc actually was several feet beyond the end frame and was coming from a supporting bolt of the brush-holder. The value of most pictures is increased when an oscillograph record of current and voltage is made simultaneously. By a convenient arrangement the pressure of a single button operates the mechanism being studied, so as to give simultaneous records. A. E. G.

340. *Ultra-rapid Kinematograph.* **H. Abraham, E. Bloch,** and **L. Bloch.** (Comptes Rendus, 169. pp. 1081–1083, Dec. 1, 1919.)—This paper describes a method by which kinematograph records may be obtained at the rate of several thousand photographs per sec. The principle of the arrangement used consists in charging up to about 5000 volts a small Leyden jar L, which discharges itself immediately across a spark-gap, and is then again charged from a high-voltage source of 12,000 to 15,000 volts. The regularity of the discharges is secured by means of a strong blast across the spark-gap, which prevents the formation of an arc. If a d.c. high-voltage machine or a battery of accumulators is not available, a large condenser C is used to form an energy reservoir. This is charged by means of a transformer or induction coil, furnished with a rectifying valve, and the condenser C is shunted by a spark-gap in series with a resistance to limit the voltage across its terminals. The condenser C is large enough (about 0·5 mfd.) to charge the Leyden jar L a great number of times without its potential being lowered appreciably. When taking photographs, the primary circuit of the induction coil is suddenly closed, and after a certain time the discharge circuit is broken, the time interval corresponding, say, to 100 or 200 photographs. The Leyden jar L has a capacity less than 1/1000 mfd., and is charged through an adjustable liquid resistance, which fixes the spark frequency. The spark-gap consists of two hemispheres of Al, polished before each operation, and the spark length is about 1 mm. With this apparatus a spark frequency of over 50,000 per sec. has been readily obtained. The photographs should be taken on a very sensitive film with very rapid motion. For this purpose a motor has been used to drive a cylinder of about 20 cm. diam. at about 6000 r.p.m. The whole apparatus is mounted in a dark room, the object being illumined by means of the series of sparks, and the camera lens being open continuously. A. W.

341. *Reflection Factors of Tungsten at Incandescent Temperatures.* **W. Weniger** and **A. H. Pfund.** (Phys. Rev. 14. pp. 427–438, Nov., 1919.)—A direct method has been developed for measuring the reflection factors of substances at incandescent temperatures. Curves are given showing the variation in the reflection factor of tungsten from 0·67 μ to 4·0 μ and for temperatures up to 2067° K.

The reflection factor of tungsten was found to increase with temperature for wave-lengths less than about 1·27 μ and to decrease with temperature for wave-lengths longer than this. The transition from the approximately constant positive temperature coefficient in the visible spectrum to the approximately constant negative coefficient in the infra-red takes place in the rather narrow region lying between about 0·7 μ and 2·0 μ. The numerical values of the reflection factor agree fairly well with Worthing's values in the visible region and with the theoretical equation first applied to long wave-lengths by Hagen and Rubens, beyond 2 μ in the infra-red. AUTHORS.

342. *Doubly Refracting Structure of Silica Glass.* **R. W. Lawson.** (Nature, 104. p. 335, Nov. 27, 1919.)—Rayleigh [see Abs. 88 (1920)] states that, with accurately crossed nicols, "a circular disc of optical quality silica showed a spiral structure." Crystalline quartz assumes a uniform yellowish-brown or brownish-red colour when "rayed" by the rays of radio-active substances; the formation of coloured streaks and of patches similar to the markings of marble has also been observed. On the other hand, fused quartz generally assumes a uniform brownish-violet colour when exposed to radium rays. Hönigschmid used fused quartz evaporating basins for recrystallising large quantities of radium chloride, and these afterwards showed a remarkable

spiral colouration. Radiating from the centre of each basin was a series of spiral-shaped streaks of a dark violet colour. The space between the streaks showed little or no colouration. The colouration disappeared on heating the dishes in a Bunsen flame, a brilliant bluish-violet fluorescence being produced. It has generally been assumed that the conditions which give rise to these "streaks" are connected with the mode of manufacture of such vessels.
A. W.

343. *Reflecting Power of Stellite and Lacquered Silver.* **W. W. Coblentz and H. Kahler.** (Bureau of Standards, Bull. 15. pp. 215–217 [Sci. Papers, No. 342], 1919.)—The object of the present paper is to give data on the reflecting power of the latest production of stellite and also of lacquered silver mirrors. It is shown that the reflectivity of stellite varies somewhat in the visible spectrum depending upon the homogeneity and no doubt upon the exact composition of the alloy [see Abs. 1156 (1918)].

Data are given on the reflecting power of lacquered silver mirrors, before and after exposure to ultra-violet light. It is shown that owing to photochemical action in the lacquer the silver is turned brown in colour, thus reducing its reflecting power. AUTHORS.

344. *Calculation of Double Refraction.* **E. Henriot.** (Comptes Rendus, 169. pp. 959–962, Nov. 24, 1919.)—The author obtains an expression of the form $\gamma_0 + (f_e - f_0)/2\pi N e^2 = (n_e^2 - 1)^{-1} - (n_0^2 - 1)^{-1}$, when n_0, n_e are the ordinary and extraordinary refractive indices, f_0, f_e the corresponding quasi-elastic coefficients of the vibrating electrons, e is the electronic charge, and N the number of molecules in unit volume. For small values of $n_e - n_0$, the right-hand side may be written in the form $2\pi(n_0 - n_e)/(n^2 - 1)^2$. The author finds that for widely differing values of $n_e - n_0$, the value of the term $(f_1 - f_0)/2\pi N e^2$ is negligible in comparison with γ_0, so that $n_e - n_0$ can be calculated when γ_0 is known. Theoretically it is shown that this was to be expected. For fluorspar compressed until isotropic he finds $\gamma_0 = -1{\cdot}51(1 + \sigma)p/E$, where E is the elastic modulus, σ in Poisson's coefficient, and p is the pressure in kg./mm.^{2}. In the case of a substance initially isotropic, such as glass, γ_0 can be calculated in a similar manner on the assumption that the molecules form a cubic space-lattice. G. W. DE T.

345. *Diffraction at a Circular Aperture due to a Luminous Disc.* **H. Nagaoka.** (Phys. Math. Soc. Japan, Proc. 1. pp. 856–862, Nov.–Dec., 1919.)—Discusses the value of the function $y = J_0^2(x) + J_1^2(x)$ which enters into the expression for the intensity of the diffracted light at the centre of the image of a uniform circular disc formed by an optical system with a circular aperture [see Abs. 752 (1898)]. J. W. T. W.

346. *Scattering of Light by Resonating Molecules.* **Rayleigh.** (Nature, 104. p. 276, Nov. 13, 1919.)—Wood [Abs. 1182 (1912)] found that mercury vapour, even at the small density corresponding to atmospheric temperatures when illuminated by the ultra-violet mercury radiation λ2536, re-emits this radiation laterally in considerable intensity. Further, Wood and Kimura [Abs. 1226 (1916)] found that this radiation is completely free from polarisation. Wood's experiments were made with the exciting light polarised, and he observed the resonance radiation through the same window by which the exciting light entered. In this way the light examined comes chiefly from the very first stratum of vapour entered by the beam. This stratum gives by far the most intense emission. As, however, the beam advances into the mercury vapour the light in exact resonance is absorbed, being, in part at least, re-emitted. The lateral emission further on is fainter, and corresponds presumably to a less exact resonance. It appeared to be of interest to examine this lateral emission from the deeper strata for polarisation. The results of the investigation are now given; the experimental details will be published later. After the unpolarised primary beam has traversed 0·4 cm. of mercury vapour at ordinary temperature, the lateral emission shows very perceptible polarisation, the component intensity vibrating parallel to the exciting beam having 90 % of the intensity of the perpendicular component. After passing through 2·5 cm. this ratio fell to 82 %, and after 27·4 cm. the value found was 60 %. Thus it appears that the scattered light is unpolarised only when resonance is very exact. The breadth of the absorption band (reversal) produced by a few mm. of mercury at atmospheric temperature and *in vacuo* must be extremely small, and probably beyond the range of any but the most powerful spectroscopes. Yet it is only within this narrow spectral range that the scattered light is sensibly unpolarised. When this component is filtered out, and such excitation as remains is by light nearer the edges of the exciting line, polarisation becomes conspicuous.

Further experiments are in progress. A. W.

347. *Colours of the Striæ in Mica.* **P. N. Ghosh.** (Roy. Soc., Proc. 96. pp. 257–266, Nov. 1, 1919.)—This paper describes the results of a fuller investigation of the phenomenon of the coloured striæ observed when mica is examined by the Foucault test, a preliminary account of which has previously been given [Abs. 42 (1919)]. The following are the principal results obtained which have been discussed in the light of mathematical theory now given:—The striæ are shown by an examination of the Haidinger's rings in mica (and also otherwise), to be the boundaries between parts having slightly different thicknesses. The colour of any stria as seen in the Foucault test is complementary to the colour of the central fringe in the laminary diffraction-pattern produced by it. The colours are altered by holding the mica obliquely, or by immersing it in a cell containing liquid. The luminosity of a stria in the Foucault test is approximately a maximum when the phases of the wave-front after passing through the plate on the two sides of the stria are opposite to one another, and is practically zero when the phases are identical. Attempts to reproduce the phenomenon by etching glass plates with dilute hydrofluoric acid were not very successful, owing apparently to a want of sufficient sharpness in the boundary line thus produced. This is indicated by the fact that such a plate shows distinct asymmetry with reference to the direction of the incident light, both in the Foucault test and in laminar diffraction. The striæ in mica appear doubled, *i.e.*, with a black line in the centre, when the light coming to a focus is screened in a symmetrical manner, instead of by a knife-edge as in the Foucault test.

The research is being continued. A. W.

348. *The Scattering Effect of Light in the Refractive Media of the Eye.* **C. V. Raman.** (Phil. Mag. 38. pp. 568–572, Nov., 1919.)—When a small luminous source is viewed against a dark background, luminous radial streamers appear to emerge from the object. Helmholtz has ascribed the effect to diffraction at the irregular margin of the pupil of the eye. The author has studied the effect further, using both white and monochromatic light. With white light the streamers are seen, and appear white but tipped with streaks of colour.

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A luminous pinhole is surrounded by a circular patch of light from which the streamers emerge. Outside is a dark ring, and then a luminous halo, strongly coloured, amidst which the streamers are seen. With monochromatic light the streamers do not occur, but instead there is a circular area filled with granular patches of light, outside this a darker ring, and then a luminous halo. These effects resemble very closely those met with when light is diffracted by irregularly placed fine particles, *e.g.*, lycopodium on a glass plate. The author concludes that the effects seen in viewing a small point of light in the manner described are due to diffraction by small particles suspended in the media of the eye, and he quotes other evidence to show that they cannot be due to diffraction at the edge of the pupil. J. S. D.

349. *A Physical Method of Heterochromatic Photometry.* **A. Blondel.** (Comptes Rendus, 169. pp. 830–835, Nov. 10, 1919.) Various methods of heterochromatic photometry, involving the use of special coloured solutions with thermopiles, etc., have proved impracticable, either because such filters are difficult to prepare and manipulate, or because the amount of energy left for measurement is too small. The method now suggested involves the production of a spectrum from the light of the source to be studied. The source illuminates a small plate placed in front of the slit of a spectroscope, and the image of the spectrum formed passes through an aperture which reduces each wave-length of radiation in the correct proportion to render the resultant transmitted energy proportional to the luminosity. The energy transmitted is then received on a thermopile, and the galvanometer connected to this gives a deflection proportional to the total luminosity. The author discusses various corrections necessary, *e.g.*, for the dispersion, and for unequal absorption of the various colours (the latter is small). In order to secure high sensibility it is desirable that the illuminated plate should be small so that it can be placed near to the source of light. The galvanometer used gives 160 mm. deflection for 1 microamp. With a 50-c.p. carbon filament lamp 80 cm. from the plate a deflection of about 10 mm. was obtained. J. S. D.

350. *The Unaided Eye.* **J. W. French.** (Optical Soc., Trans. 20. pp. 209–232; Disc., 233–236, April, 1919, and 21. 1. pp. 1–24; Disc., 24–33, 1919–20.)—The first part of this paper deals with the physiological details of the eye. The author then goes on to discuss the question of pupil diameter. Curves are given showing the variation of the iris pupil diameter as the light varies from about zero to unity; others show the pupil area as related to log relative illumination. From these the relation, area of pupil $= \kappa(\text{illumination})^{1/6}$ is obtained, for two observers (left eye); for the same observers the right eye gave 1/5·2 as the exponent. L. H. W.

351. *Graticules.* **J. Rheinberg.** (Optical Soc., Trans. 20. pp. 277–292, May, 1919.)—Describes the different forms of graticules available both from British and foreign sources before the war, and the difficulties underlying any photographic method of graticule reproduction. A description is then given of the results obtainable by two new methods, namely, grainless photography and filmless photography. In the latter the image lines are formed, in the surface layer of the glass itself, in untarnishable metal so that they cannot be rubbed off, and are even unaffected by any solvents except those which attack the glass itself. The process by which these results are obtained is not described. The image lines may be opaque or of any

required degree of transparency, and it has been found that for many purposes a transparent line is preferable to an opaque one, particularly where the graticule pattern is at all complicated or extensively figured. In the grainless process a collodion film is used, but in the filmless process the surface layer of the glass forms the film, and it has been found that the best results are obtained with crown glass and that glass with any appreciable proportion of lead is unsuitable. The problems of accurate scale reproduction are dealt with at length, and detailed instructions are given for the drawing of the pattern to be reproduced. Finally a number of microphotographs of actual graticules with lines between 0·001 and 0·0004 in. are given. J. W. T. W.

352. *Aberrations of a Lens System.* **A. E. Conrady.** (Roy. Astron. Soc., M.N. 80. pp. 78–91, Nov. 1919.)—In continuation of previous work [see Abs. 286 (1919] it is shown that the curvature of the sagittal field of a lens system may be safely derived from the extended Petzval theorem without separate calculations, in all cases where the Petzval curvature corresponds to a radius of the order of the focal length of the system (with all ordinary glasses and lens-types the radius of curvature ranges from 0·75 to 1·6 times the focal length) provided no angle of incidence or obliquity exceeds about 20°. The author goes on to consider some results of the general theory given in the first paper. An investigation of the influence of the position of the diaphragm leads to a treatment of the properties of oblique pencils and the simplification of their calculation under certain conditions. J. W. T. W.

353. *Spacing of Glass-working Tools.* **T. Smith.** (Optical Soc., Trans. 20. pp. 237–258; Disc., pp. 259–269, April, 1919.)—Proposes a formula for the calculation of radii of a series of tools such that the departure of one tool of the series from the radius required by calculation in any particular case may always be within the limits admissable on such a radius. The system proposed extends over the whole range from the smallest microscope objectives to telescope objectives of such diameters as 200 mm. For radii of the order of ten metres and upwards, the best system of spacing is one in arithmetical progression of curvatures. Tables are given, at the conclusion of the paper, showing the radii in mm. and the curvatures in dioptres of a proposed set of 1000 tools calculated on the system proposed. It is shown that the distribution of the tools over the series is very close to that which is found actually to obtain in manufacturers' existing lists. An example is given of the accuracy to which requirements can be met, in any particular case, by the tools of such a series.

In the *discussion*, **H. Lee** gave examples of a different system based on empirical differential equations chosen with a view to the limits imposed by practical considerations. **F. Twyman** said that it was impossible to base a standard of definition on the area of the image patch at any particular plane near the focus. J. W. T. W.

354. *The Emulsion for a Process Plate.* **R. E. Slade** and **G. I. Higson.** (Phot. J. 59. pp. 260–265, Dec., 1919.)—In the course of an investigation of the photochemical laws governing the action of light upon a photographic plate the authors found that under ordinary conditions of exposure the shape of a plate curve (as determined by Hurter and Driffield's method) is dependent on: (1) the relation of the different sizes of grains in the plate to each other and the quantity of each present; (2) the thickness and

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opacity of the film; (3) the time and method of development. Of these factors, the first, which has not previously been noticed, is the most important. If the grains are all of the same size we get the steepest curve possible. If the grains are of more than one size a flatter curve is obtained: the curve in the latter case being really the sum of the curves due to each group of particles of the same size. In a process plate as steep a curve as possible is required. Since the steepest curve is obtained with all the grains of one size, this is the type of emulsion for a process plate or for a hard or vigorous paper. Moreover, as the effect of a single grain on the blackening is proportional to the quantity of silver bromide it contains, we may say that as much as possible of the silver bromide in a process plate should be in grains of the same size. The presence of a small number of grains larger than the majority will have a worse effect than the presence of the same number of smaller grains, because the larger grains give rise to more silver on development. The absolute size of the grain does not seem to matter very much so long as they are all the same size, though as the grains become larger the opacity of the film becomes greater and the steepness of the curve falls off to some extent for this reason. Some process plates on the market are excessively slow, but give excellent results. The grain in these plates is too small to be resolved by the microscope, and it is therefore impossible to determine whether all the grains are of one size, though probably this is the case.

A note is added dealing with the preparation of microscopic slides of emulsions. A. E. G.

355. *A Property of the Photographic Plate analogous to the Purkinje Effect. Second Note.* **J. A. Parkhurst.** (Astrophys. J. 50. pp. 290–294, Nov., 1919.)—In a former note [see Abs. 888 (1919)] the effect of star-colour on the contrast of the photographic plate was investigated for the case of the ordinary plate, the results apparently confirming Abney's statement that the gradation of the plate increases as the wave-lengths of the light employed depart from that to which the plate is most sensitive. The amount of this increase for Seed 27 plates was found to be so slight that it is usually masked by accidental errors. This second note is thought to be necessary on account of the appearance of a paper by F. C. Jordan on "The Colour-Changes of Variable Stars" [Abs. 209 (1920)]. As the result of a discussion of star tables given, it is now concluded that the effect of star-colour on the gradation (contrast) of the photographic plate is small, being of the same order as the accidental errors. The direction of the change in gradation is found to agree with Abney's law that it should increase as the wave-length of the light employed departs from that to which the plate is most sensitive. This is found to be true for the ordinary plate, giving photographic magnitudes; and also for the combination of Cramer trichromatic plate and yellow filter, giving photo-visual magnitudes.

A. E. G.

356. *The Fundamental Law for the True Photographic Rendering of Contrasts.* **F. F. Renwick.** (Phil. Mag. 39. pp. 151–154, Jan., 1920.)—From the paper by Porter and Slade [see Abs. 1192 (1919)] it would appear that the more general method adopted by the author in treating this part of the subject in the nineteenth Traill Taylor Memorial Lecture [Abs. 126 (1917)] is not self-evident. Inasmuch as that method, unlike the one described by Porter and Slade, is not restricted to exact nor even to propor-

tionally correct reproduction, but can be employed with equal facility for any desired relation between the original and the final copy, it is thought worthy of record. Two cases are described in detail with the aid of diagrams. In the first case two continuous curves represent the characteristic curves found for the negative and positive materials to be used. It is desired to deduce from them the gradation curve of a positive print made under the same conditions (development, etc.) as were employed when these curves were obtained. In the second case the two continuous curves represent the characteristic curve of the negative material and the desired gradation of the finished print respectively. It is required to find what form of characteristic curve for the positive material would be necessary to obtain the desired result. In an addendum the author states that the validity of the neat proof given by Porter and Slade of the necessary relations between positive and negative, if exact reproduction is required, is unaffected by the obscurities and omissions to which reference is made. A. E. G.

357. *Chemical Induction in Photographic Development. I. Induction and the Watkins Factor.* **S. E. Sheppard** and **G. Meyer.** (Phot. J. 60. pp. 12–21, Jan., 1920.)—In previous investigations on the theory of development it was shown that the early stage of development is subject to induction effects, variable from one developer to another and in each case a function of the bromide concentration. In particular it was shown that the action of bromide as a photographic restrainer consisted primarily in extending the induction period, or delaying the initial precipitation of silver; equations for the velocity of development, taking account of the initial retardation, were developed. It was pointed out that while this initial induction is greatly extended by bromide, it exists in the absence of bromide, particularly in the case of hydroquinone. With this developer it becomes more marked on lowering the temperature. In general, the induction is greater the less the reduction-potential of the developer. As the result of the present investigations it is concluded that the Lainer effect (acceleration of development by dilute soluble iodides) affects chiefly organic developers of low reduction-potential, such as hydroquinone. The principal effect is to overcome the induction with such organic developers, consequently increasing the Watkins factor. The effect is ascribed to increased absorption and complex formation as between silver halide and developer. The bearing of this on the theory of development is discussed. In addition, there is a fogging action of dilute potassium iodide solutions on silver bromide emulsions, which is ascribed to nucleus infection of the grain. A. E. G.

358. *Hypersensitising Commercial Panchromatic Plates.* **S. M. Burka.** (Frank. Inst., J. 189. pp. 25–46, Jan., 1920.)—Ordinary dry plates, which owe their sensitivity to the silver halides alone, are sensitive only to the violet and blue regions of the spectrum. If, however, a suitable dyestuff be added, the emulsion becomes sensitive to other regions, the particular region depending on the dye used. Thus erythrosin sensitises to the green and greenish-yellow, pinaverdol to the green and yellow, pinacyanol to the orange and red, and dicyanin to the extreme red and infra-red. The dyestuff is applied to the halides in one of two ways. In the commercial orthochromatic and panchromatic plates the dyes are incorporated in the emulsion and the mixture flowed over the glass plate. The second method consists of bathing an ordinary blue-sensitive plate in a dilute solution of the dye and allowing the plate to dry. The bathed plates are in general faster than the commercial plates and, of course, have the advantage that the plates can be sensitised for any desired region. Certain dyes, moreover (dicyanin, for example), cannot be successfully incorporated with the emulsion. The bathed plates, however, if not used soon after bathing, or if kept at a high temperature, are, in the case of most dyes, more susceptible to chemical fog. Dicyanin and pinacyanol bathed plates, when prepared so as to produce the greatest sensitivity, are useless after three or four days.

It has long been known that, though at the expense of keeping qualities and freedom from chemical fog, the speed of the bathed plates can be increased by the addition of ammonia to the dye-bath. Since this increase is quite marked in the case of some dyes, it was hoped that in this way commercial plates could have their speed increased. This forms the object of the present investigation. In the course of the work three methods of sensitometry are used. Of these, one is used as a first qualitative test; the second, the spectrograph method, is used to study the effect of the ammonia on the sensitivity of the plate to each wave-length; the third, the Hurter and Driffield method, gives the absolute value of the speed of the plate. It is found that by bathing commercial panchromatic plates in a solution of 25 cm.^{3} ethyl alcohol, 75 cm.^{3} water, and 8 cm.^{3} of strong ammonia water (20 % NH_3) for 4 minutes at 18° C. and drying rapidly, the speed to white light is increased 100 % in nearly all cases, and the sensitivity in the red extends 100 or more Ångström units. The speed in the red is in many cases increased 400 %. If the plates be bathed without the alcohol (100 cm.^{3} water, 8⅓ cm.^{3} ammonia water), the speed is still further increased; the plates, however, should be used immediately after drying. Ordinary plates do not have their sensitivity appreciably changed. Most brands of orthochromatic plates are not improved, although one, the Cramer Trichromatic, showed the same increase as the panchromatic plate.

The paper is well illustrated with curves and photographic records. A. E. G.

359. *Light and Gravitation.* **O. J. Lodge.** (Phil. Mag. 38. p. 737, Dec., 1919; also Nature, 104. p. 354, Dec. 4, 1919.)—Einstein's great achievement is to associate gravitation with the electrical phenomenon called light as it has long been with the electrical phenomenon called matter. Motion of matter affects inertia, and that of light seems to generate inertia. Einstein's result would follow the assumptions identifying light-mass and its kinetic energy, light-weight and its whole energy [Abs. 1348 (1917)]. Another view would be that neighbourhood of matter modifies the specific inductive capacity of otherwise free space, extending to gravitation field a trace of the effect known in cohesion field. A spherical field of refractivity varying as the gravitational potential would then bend a ray so that $\int \mu ds$ is stationary, and give a deflection inversely as shortest distance between ray and centre of attraction, as fact requires. The former view seems simpler, but both require a detailed theory of weight not yet attained. The second paper contains further remarks on points dealt with in the first. G. W. DE T.

360. *Deflection of Light during Solar Eclipse.* **A. Anderson.** (Nature, 104. p. 354, Dec. 4, 1919.)—The author argues that the observed bending of the light rays passing near the sun may be accounted for by abnormal refraction arising from a reduction of air temperature during passage through the shadow cone. **A. S. Eddington, A. C. D. Crommelin.** (*Ibid.*, pp. 372–373, Dec. 11, 1919.)—Eddington estimates that the effect of abnormal refraction might amount to as much as 1/20 of the Einstein deflection, and suggests that possibly the rather high value found at Sobral has been increased by this cause. At Principe there was no perceptible change of temperature during the eclipse, but the climatic conditions there are exceptional.

Crommelin also thinks that not more than a very small portion of the effect observed at Sobral could arise from abnormal refraction. He also states that the photographs were taken at Sobral at uniform intervals throughout totality, and all give tolerably accordant values of the shift, and shows that this would not be the case if the effect were due to the cause suggested by Anderson. Moreover, the fall of temperature at Sobral during totality was very small, doubtless owing to the cloudiness before totality. **W. H. Dines, L. F. Richardson, A. Anderson.** (*Ibid.*, pp. 893–894, Dec. 18, 1919.)—Dines and Richardson both argue that the effect of abnormal refraction would be far too small to give rise to the observed bending.

Anderson recognises the force of the objections raised to his view, but points out that the problem of air refraction during a total eclipse is very complicated, and that the stars in the neighbourhood of the sun at such a time must be viewed through air of which the distribution of density must not be assumed to be the same as that of the atmosphere in its normal state. **A. Anderson.** (*Ibid.*, p. 486, Jan. 1, 1920.)—Anderson restates his contention in the form: If we imagine the normal atmosphere removed, we are left with a residual atmosphere the refraction effects of which will be changes in the normal refraction effects. The whole point is whether, on reasonable suppositions, this residual atmosphere can produce refraction effects of the order of those observed. Supposing with Eddington that the portion of this residual atmosphere concerned corresponding to a star near the edge of the sun's disc has a radius of about 150 yards, he points out that, when θ_1, θ_2 are the falls of temperature at the centre and circumference, the greater the value of $(\theta_2 - \theta_1)/\theta_2$, the smaller is the necessary fall at the centre to produce the observed effect, and claims that a perfectly reasonable assumption as to the temperature gradient achieves this result. G. W. DE T.

361. *Reflection of Particles in Long Tubes.* **R. W. Lawson** and **V. F. Hess.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 535–562, 1918.)—The complete paper corresponding to Abs. 807 (1919).

362. *Some Photographic Apparatus used in Aerial Photography.* **C. W. Gamble.** (Optical Soc., Trans. 20. pp. 168–198, March, 1919.)—Deals in a general way with the lenses, cameras and camera fittings used for this branch of photography. Much useful information is given. L. H. W.

363. *On Fresnel's Convection Coefficient.* **A. Anderson.** (Phil. Mag. 39. pp. 148–151, Jan., 1920.)—A geometrical treatment.

364. *Elementary Theory of Terrestrial Refraction and Atmospheric Reflection.* **J. Würschmidt.** (Ann. d. Physik, 60. 2. pp. 149–180, Sept. 26, 1919.)

365. *The Kinematics of the Eye.* **H. Lamb.** (Phil. Mag. 38. pp. 685–695., Dec., 1919.)—This subject should be of interest to mathematicians, for, according to the author, it is almost the only field where the theory of Finite Rotations finds a practical application. L. H. W.

366. *Polarisation of Light scattered by Helium Atoms.* **Rayleigh.** (Nature, 104. p. 412, Dec. 25, 1919.)—The statement made by the author in a former paper [Abs. 41 (1919)] that helium gives much less complete polarisation than

other gases is here stated to be incorrect. A repetition of the experiments with greatly improved apparatus leads to the conclusion that “ if helium is outstanding at all, it is in the direction of polarising more, and not less, completely than the generality of gases. G. W. de T.

367. *Intensity Relations in the Spectrum of Helium.* **T. R. Merton** and **J. W. Nicholson.** (Roy. Soc., Phil. Trans. 220. pp. 187–178, Dec. 28, 1919.)—Three factors have been shown to affect the distribution of intensity among the lines of a spectrum : (1) The electrical conditions of excitation ; (2) the presence of impurities ; (8) the pressure of the gas in the discharge tube. Thus it is desirable to investigate the simplest possible cases in which the nature of any changes introduced into the method of excitation of the spectrum can be followed in some detail. After discussing briefly various kathode-ray phenomena, a description is given of the experimental methods employed in the present investigation. A study was made of the helium spectrum as a function of the kathode distance. In this connection a comparison was made of the principal, sharp and diffuse series, and of helium and parhelium. The regions of max. emission were also studied. It was found that as the kathode distance is increased, there is no definite change of relative intensity in the components of any helium series, with the possible exception of a slight enhancement of the first member in the diffuse series at a considerable distance from the kathode. Parhelium, on the other hand, is in striking contrast. Earlier members of its series are enhanced at the expense of later members at the extremity of the dark space. Beyond this point the phenomenon is gradually reversed, until finally there is a definite enhancement of later members at the expense of those of lower term-number. The difference of behaviour of the single-line and doublet series must be of importance to any discussion of their origin. From a general point of view, it appears to imply at least that the two sets of series are not produced from the same atoms. The seat of max. emission in helium is the same for lines of the same series, and is peculiar to that series, whilst in parhelium its position is affected by the term-number of the line in the series. The band spectrum is restricted to very narrow limits as regards the conditions of excitation. The seat of max. emission is widely different for lines of helium, hydrogen, and mercury. When the pressure in the discharge tube is very low, an entirely different phenomenon is observed. Instead of a *progressive* transfer of energy in the series, there is a *selective* transfer peculiar to certain lines. In particular the lines λλ4388, 4472, and 5015 are relatively enhanced under these conditions, whilst λ3888 is reduced. As regards the behaviour of mixtures of helium and hydrogen, the results have not the same quantitative significance, in the sense that there must be small differences in the pressure of the gas in different tubes. Taking account of this and other sources of error, there are still changes which appear to be peculiar to the conditions obtaining in the mixed gases. In mixtures of hydrogen and helium, where the partial pressure of each gas is of the same order of magnitude, there is in general a transfer of energy in the spectra of both gases to the lines of higher term-number in comparison with the distribution of intensity in the spectrum of helium, which was so pure that the hydrogen spectrum could not be seen. On the other hand, in the presence of a “trace” of hydrogen, the helium lines are affected in the opposite sense, *i.e.*, there is a transfer of energy to the members of lower term-number. It is remarkable that the addition of a trace of hydrogen affects both the diffuse and the sharp series to a comparable extent, whilst the inverse effect produced by a larger quantity of the

lighter gas, affects the diffuse series to a much greater extent than the sharp series. A. W.

368. *Spectra emitted by the Red Fringe and the Luminous Vapour in the Neighbourhood of an Incandescent Plate of Graphite.* **G. A. Hemsalech.** (Comptes Rendus, 169. pp. 1084–1086, Dec. 1, 1919.)—A continuation of work previously described [see Abs. 253 (1920)]. The spectra obtained, which are largely derived from impurities in the graphite and from the carborundum powder used, are described in detail, and particulars are given of the way in which the spectral intensity varies with distance from the graphite plate. The effect of a magnetic field is also discussed. The intensity of all the lines and bands diminishes gradually with distance below the plate, which shows they are controlled by the temperature of the plate. In particular, the iron spectrum is exactly of the same type as the author has previously observed in flames and in the tube-resistance furnace [Abs. 1159 (1918)]. The author concludes that the band and line spectra of the vapours in question are due to two different kinds of emission centres: (1) those created by the action of heat on metal carbides, the spectrum of which is controlled by the temperature of the plate (thermochemical excitation): these centres of emission are not sensibly affected by a magnetic field; and (2) those produced by the thermoelectronic current, the spectrum of which is controlled simultaneously by the thermal and electric conditions (thermoelectric excitation): these centres of emission are very susceptible to magnetic forces. A. W.

369. *Origin of Radiations emitted by the Vapours in a Tube-Resistance Furnace.* **G. A. Hemsalech.** (Comptes Rendus, 169. pp. 1092–1095, Dec. 8, 1919.)—Further experiments have been carried out with apparatus in which two exactly similar graphite plates [see preceding Abs. and No. 253 (1920)] were used one above the other at a distance of 5 mm. With this improvement the red fringe was obtained at a temperature of 2200° C. with a fall of potential of only 4 volts/cm., and the fringe filled the whole space between the plates. The arrangement has other advantages, which are discussed. The facts observed led to further experiments with the tube-resistance furnace. With this it was found that the characteristic bands of the red fringe could be obtained at about 2100° C. with a fall of potential of less than 1 volt/cm. The experiments have shown that the spectra given by Al, Ca, Mn, K, Sr, Pb, Cr, and Fe in the tube furnace and in the luminous vapour above a graphite plate are exactly of the same type, and therefore caused in the same way. A. W.

370. *A Mechanical Theory of Series Spectra.* **A. Korn.** (Phys. Zeits. 20. pp. 491–494, Nov. 1, 1919.)—In this communication a knowledge of the author's mechanical theory of the electromagnetic field is not assumed [see Abs. 1026 (1918) etc.], although this likewise leads to a mechanical theory for series spectra. The fundamental basis of the electromagnetic theory of light is adopted wherein an electromagnetic field is regarded as the cause of light-phenomena: light being produced by the mechanical oscillations of electrical particles whose vibration frequencies may lie between the limits which have been designated as the limits of the visible spectrum. The quanta theory is not invoked, although many important results for spectra produced by its aid (starting from Bohr's conceptions [see Abs. 1930 (1918)]) can find a place in the author's mechanical theory.

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In previous mechanical theories of spectra, which regard the spectra as particular oscillations of elastic systems, *e.g.*, the theories due to Ritz and Lindemann, the differential equations were derived for a particular elastic system so that the special frequencies corresponded to the formulæ of Balmer, which latter are general formulæ like those of Kayser and Runge for the frequency of the spectral lines. The present author now proceeds as follows:—As in classical mechanics two particles of masses m_0 and m, and for simplicity taken as spherical, whose radii are small compared with the distance r between the centres, exert a force $f(r)$ which is a certain function of r, an indispensable assumption in a mechanical theory, and which is to be explained by means of the particle oscillations and an intervening medium. The function $f(r)$ may be so chosen that $r = r_0 + \epsilon(t) \cos 2\pi t/\mathrm{T}$, where r_0 is a constant distance, T a constant small interval, and the function $\epsilon(t)$ small compared with r_0. The author has now succeeded in finding a function $f(r)$, whereby a plurality of motions are possible, *e.g.*, $r = r_{\nu 0} + \epsilon_\nu(t) \cos t/\mathrm{T}_\nu$, where $\nu = 1, 2, \ldots$, and where $\mathrm{T}_1 > \mathrm{T}_2 > \ldots$ are oscillation periods such as occur in a spectral series. Such a function is $\mathrm{F}(r) = (\alpha + \beta/r^n) \cos 2\pi r/\lambda + 2\pi\gamma/3\lambda r^2 \sin 2\pi r/\lambda$, in which α, β, γ, λ are constants corresponding to the required demands. This constitutes the subject matter of the present paper, while the derivation of the law of interaction from the particle oscillations in a medium together with further consequences is reserved for a later communication. H. H. Ho.

871. *Secondary Spectrum of Hydrogen.* **T. R. Merton.** (Roy. Soc., Proc. 96. pp. 382–388, Jan. 2, 1920.)—A discussion is first given of earlier work on the hydrogen spectrum [see Abs. 1190 (1912) and 417 (1918)]. Experiments are then described with reference to the secondary spectrum of hydrogen. It was intended to make an attempt to resolve the spectrum into groups of lines which showed a similar behaviour under different physical conditions, by investigating in the first instance the changes in the relative intensities of the lines which accompany a change of pressure in the discharge tube, the intensities being measured by means of the wedge method [Abs. 1182 (1917)], and a number of experiments have been conducted on these lines. The results showed that the Fulcher bands [Abs. 417 (1918)] become relatively brighter at low pressures, and at the same time there is a marked enhancement of the lines in the region of about λ5700 to λ5000 Å.U. In the more refrangible region there is no conspicuous change in the relative intensities, but the intensity of the continuous spectrum is reduced at low pressures. It has been found that when hydrogen at a partial pressure of less than 1 mm. is present in helium at a pressure of about 40 mm., the spectrum is remarkably different from that of pure hydrogen. The spectra have been photographed in the first order of a concave grating of 4-ft. radius and 20,000 lines to the inch, which was mounted according to Eagle's method, the dispersion being almost exactly 10 Å. per mm. Photographs in juxtaposition were taken with this instrument of (1) a high-pressure helium-hydrogen tube and (2) a tube containing pure hydrogen at a pressure of a few mm. The tubes were excited by the uncondensed discharge of an induction coil. In the more refrangible parts of the spectrum there is little difference, but in the red and yellow regions it is found that a large number of lines are greatly enhanced in the tubes containing helium, some of these being extremely faint in the spectrum of pure hydrogen, and that a number of new lines appear. There is another class of lines whose relative intensities are unaffected by the presence of helium, whilst a third class are affected in the sense that they become very weak or disappear. The magnitude of the changes observed leaves little room for doubt that a separation of the lines into physically related groups has been effected. A photograph is reproduced, and a table given of lines which are either enhanced or unaffected in intensity by the admixture of helium. It will be of interest to discover whether the above changes in the spectrum of hydrogen can be reproduced in any other way. Hitherto all attempts involving a change in the conditions of electrical excitation have failed, but it is not unlikely that other elements in the group of inactive gases will be found to resemble helium in their effect. At present no explanation of the phenomena can be given. A. W.

372. *Helium Series in the Extreme Ultra-Violet.* **T. Lyman.** (Nature, 104. p. 314, Nov. 20, 1919.)—It has been shown that the helium series first discovered in a terrestrial source by Fowler can be represented by the formula $\nu = 109750\left[\left\{1/(n_1/2)^2\right\} - \left\{1/(n_2/2)^2\right\}\right]$, where n_1 has the value 3 or 4 [see Abs. 551 (1915) and 778 (1916)].

If n_1 be given the value 2, and n_2 the successive values 3, 4, and 5, lines result at wave-lengths 1640·1, 1214·9, and 1084·7. The author's previous investigations of the helium spectrum did not afford much evidence as to the existence of these lines, but a recent search has been more successful. With a powerful disruptive discharge in helium, a sharp, fairly strong line appears at λ1640·2; no trace of it is found in hydrogen under the same electrical conditions, and it does not occur in helium when the discharge circuit is free from capacity. Under the same violently disruptive conditions the line at λ1216, always present in helium and hydrogen, develops a satellite on its more refrangible side. This satellite is not well resolved, but its wave-length appears to be about 1215·1. The region that should be occupied by λ1084·7 is obscured by a strong pair at λ1085, probably due to an impurity. It seems very probable that two members of the above helium series have been found in the extreme ultra-violet, but it is not claimed that the evidence is conclusive. A. W.

373. *Helium Series in the Extreme Ultra-Violet.* **W. M. Hicks.** (Nature, 104. p. 393, Dec. 18, 1919.)—Lyman [see preceding Abs.] has reported observations of a helium line at 1640·1, as well as a weak one at 1215·1, close to the strong one 1216, and refers them to orders 3, 4 in the series $4\,N\left\{1/2^2 - 1/m^2\right\}$. If the correct reading for the strong line is nearer the 1215·1, the whole series $m = 4 \ldots 8$ is found in Lyman's list of ultra-violet lines [Abs. 778 (1916)]. The following is the list of observed lines with deviations (obs. — calc.) from the calculated values, with $N = 109720$:

Order.	Intensity.	λ.	dλ.
3	Strong	1640·2	− 0·34
4	10	1215·1	− 0·11
5	5	1086·1	+ 1·08
6	4	1026·0	+ 0·66
7	3	992·0	− 0·37
8	1	972·7	+ 0·59

The line 1084·9 is closer to the calculated, with $d\lambda = -0{\cdot}11$, but its intensity of 2 is not in step with the others. In estimating possible errors,

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those of standards as well as of observation have to be considered. With uncertainties also of formulæ, the values of $d\lambda$ do not seem excessive.

A. W.

374. *Spectra of Isotopes.* **T. R. Merton.** (Roy. Soc., Proc. 96. pp. 388–394, Jan. 2, 1920.)—By making certain novel refinements in the method of measuring the interference fringes obtained by means of a Fabry and Perot étalon, the author has been able to detect and measure with a considerable degree of accuracy small differences (of the order 0·001 Å.) in wave-lengths of isotopic elements. In the method employed the element to be examined is alloyed with cadmium and all observations are reduced to a selected fringe of cadmium as a standard. The Cd green line $\lambda = 5086$ Å. was used as this standard in some cases, $\lambda = 4800$ Å. in others. A whole fringe for the lead line $\lambda = 4058$ is $\epsilon = 0{\cdot}084$ Å.; and for the thallium line $\lambda = 5350$, $\epsilon = 0{\cdot}146$ Å. By measuring fractional displacements of a fringe it has proved easily and decisively possible to distinguish optically between the various isotopes of lead and thallium. Thus it was found in the case of lead isotopes:

λ (lead from pitchblende) − λ (ordinary lead) = 0·0050 Å. ± 0·0007 Å.
λ (ordinary lead) − λ (thorite lead) = 0·0022 Å. ± 0·0008 Å.

Similarly for thallium isotopes:—

λ (ordinary thallium) − λ (thallium from pitchblende) = + 0·0055 Å. ± 0·0010 Å.

The difference found between λ (ordinary lead) and λ (lead from pitchblende) agrees within the limits of error with the value found by Aronberg [Abs. 678 (1918)], and this confirmation of his result would seem to establish the reality of the difference. The line in lead from pitchblende has a slightly longer wave-length than in ordinary lead, whilst the wave-length of the line in thorite-lead is somewhat shorter. They are thus arranged in the order of their atomic weights, and in the direction which would be anticipated by the analogy of corresponding lines in the spectra of different metals belonging to the same group in the periodic system.

The physical width of the lines, in examining mixtures of the isotopes, rendered experiments on the "doubling" of the fringes inconclusive. Further experiments in this direction are contemplated, and it may be possible to show by another method of experiment that the line in the mixture is a doublet.

The author draws attention to certain peculiarities in the fringes of thallium isotopes.

In conclusion the author remarks: "The results in the case of lead seem so definite that the spectroscope may yet prove to be a most valuable weapon in attacking the problem of isotopic elements." [See also Abs. 105 (1920).]

A. B. W.

375. *Spectra of Atomic Systems with Complex Nuclei.* **L. Silberstein.** (Phil. Mag. 39. pp. 46–66, Jan., 1920.)—When the nucleus is a simple point charge, then for a stationary orbit, on purely Newtonian principles, the negatived total energy is given by $W/ch = \kappa^2 R/n^2$, where n is an integer, c the light velocity *in vacuo*, h Planck's constant, R the Bohr expression of Rydberg's constant, and κ the atomic number. A nucleus consisting of two point-charges is the only case susceptible of rigorous solution for any dimensions of orbits. This is given and briefly dealt with. But the only orbits spectroscopically relevant are those of very large dimensions relatively to the nucleus, so that only those need be considered for which the ratio of the distance between the nuclei to the radius vector from the mid-point to the electron is permanently a small fraction. Then it is simpler even for this case to treat the atomic system as one with a point-charge nucleus subjected to slight perturbations. By a theorem of Bohr, here extended tentatively to three dimensions, $W = W_0 + \bar{F}$, where W_0 is the undisturbed value of W and $\bar{F}$ is the average value of the disturbing function F for a period of the undisturbed motion, the planetary elements entering into $\bar{F}$ being quantised exactly as in the principal term W_0. Moreover, the formulæ so obtained hold good for any atomic systems with axially symmetrical nuclei by the mere replacement of α by $\gamma = 2\pi Rcha/e^2$, a pure number. $\bar{F}$ is found to contain four of the elements of the undisturbed orbit, viz., the parameter, inclination and eccentricity, and the longitude of perihelion. The first three only can be quantised. The last remains free to assume any value between 0 and 2π, and so gives rise to diffuse lines. Quantising the former, the resulting formulæ show that if the centres coincide ($\alpha = 0$, $\gamma = 0$), there will result an ordinary Balmer series of simple lines. The complexity of the nucleus, causing a general shift of the spectrum, will depend on the value of γ^2. The deviation from the Balmer type can become dominant by increasing γ, or in the case of strongly eccentric orbits. In the cases of nuclei non-symmetrical axially, the longitude of the node, hitherto irrelevant and physically meaningless, becomes a further source of broadening of the spectrum lines. For it, again, cannot be quantised.

G. W. DE T.

376. *Anomalous Zeeman Effect.* **T. van Lohuizen.** (K. Akad. Amsterdam, Proc. 22. 8. pp. 190–199, 1919.)—The question with which this paper deals is the following: Does the magnetic resolution of spectrum lines depend solely on the initial and the final path in which the electron moves, or does the transition play some part in it? In other words, is the formula $\nu = (w_1 - w_2)/h$ valid in the presence of a magnetic field, or should it be replaced by a formula $\nu = (w_1 - w_2)/h \pm eM/4\pi mc$ as Bohr supposes? [Abs. 46 (1919).] The discussion here given leads to the conclusion that the first formula holds good.

A. W.

377. *Theory of a Method for obtaining the Distribution of Energy in a Narrow Spectrum Region from the Distribution of Energy observed in an Interferometer.* **K. F. Niessen.** (K. Akad. Amsterdam, Proc. 22. 8. pp. 200–224, 1919.)—A mathematical paper which does not admit of brief abstract.

A. W.

378. *Band Spectra.* **T. Okaya.** (Phys. Math. Soc. Japan, Proc. 1. pp. 332–348, Nov.–Dec., 1919.)—In previous papers [Abs. 1089 and 1204 (1919)] the author has shown the existence of a relation between the heads of the bands due to the different elements belonging to the same group in the periodic system. The relation applies to groups of banded spectra which diverge gradually towards the red, and has been shown to apply to the elements of the gold group and also to that of the alkaline earths. In the present paper it is shown that the relations in question hold only for the group of bands emitted by elements of the same group, and do not hold for elements belonging to different groups.

A. W.

379. *Duration of Light Emission from Atoms, and Damping of Spectral Lines.* I. **W. Wien.** (Ann. d. Physik, 60. 7. pp. 597–687, Dec. 9, 1919.)—

For the experimental work here described a special canal-ray tube was employed. The tube was 3 cm. in diam., and a hole 5 mm. in diam. was bored through the kathode, which fitted the tube. The end of the tube was sealed into a deep groove cut in a slightly wider metal cylinder, so that the kathode was in contact with this cylinder, through which the 5-mm. hole was continued. On the under side of the cylinder was fixed a copper plate 1 mm. thick, in which a slit 3 mm. long and 0·1 or 0·25 mm. wide was cut. Through this slit the canal rays issued in a small beam into the observation chamber. The latter was evacuated by 10 diffusion pumps working in parallel, a rotating mercury pump providing the preliminary exhaustion. Measurements showed that with the 0·25 mm. broad slit the ratio of the pressure in the observation chamber to that in the discharge chamber was about 2 %. There is a marked difference between the phenomena observed when a canal ray enters a space at the same pressure as the discharge chamber and those observed when the observation chamber is at a considerably lower pressure than the discharge chamber. In the former case the radiation is diffuse; its brightness increases in consequence of the scattering, but remains considerable for some distance. In the latter case the brightness increases rapidly, but at a distance of a few cm. the brightness becomes very small. With the above apparatus measurements were made of the decay of intensity of different spectral lines, using a quartz spectrograph in conjunction with an absorbing trough. The latter consisted of a parallel-sided glass vessel provided with a division along a diagonal, giving two wedge-shaped sections, one of which was filled with water and the other with a liquid of known absorption index. The results are presented in a series of tables and graphs for a number of lines in the spectra of hydrogen and oxygen. The results show no marked difference in the rate of decay for the lines H_α, H_β, and H_γ, but the values obtained are in fair agreement with the damping constants calculated from the electron theory, using the formula $2a = 8\pi^2 e^2/3mc\lambda^2$. The results for oxygen were similar to those for the hydrogen lines, the damping constant ($2a = 6 \cdot 55 \times 10^7$ sec.$^{-1}$) being very close to the values found for hydrogen.

The paper concludes with theory. [See Abs. 780 (1916) and 897 (1919).]

A. W.

380. *Fluorescence and Absorption of the Uranyl Sulphates.* **E. L. Nichols** and **H. L. Howes.** (Phys. Rev. 14. pp. 293–305, Oct., 1919.)—The spectra of the uranyl sulphates, when resolved by excitation at the temperature of liquid air, exhibit fluorescence series whose frequency intervals range from 85·7 in cæsium uranyl sulphate to 83·0 in potassium uranyl sulphate. The shift towards the violet with increasing molecular weight of the compound is unusually large. The absorption bands extend into group 7 of the fluorescence spectrum without break of interval, and there are many reversals where fluorescence and absorption overlap. AUTHORS.

381. *Line Spectrum of Sodium as Excited by Fluorescence.* **R. J. Strutt.** (Roy. Soc., Proc. 96. pp. 272–286, Nov. 1, 1919. Bakerian Lecture.)—In previous papers [Abs. 1045 and 1532 (1915)] the author has described experiments on the resonance spectrum of sodium vapour. The results of these experiments are summarised in the present paper; in addition, details are given of improvements in the sodium-vapour vacuum arc in quartz used in later work. The conditions have been studied for steady running of the lamp, and for getting the right kind of radiation to excite brilliant resonance

with D light. It is found that excitation of sodium vapour by the second line of the principal series leads to the emission of both λ8808 and the D line. On the other hand, as might be anticipated, excitation of the D line leads to the emission of the D line only, with λ8808. When D light falls on sodium vapour of appropriate density, it is known that an intense surface emission occurs from the front layer, and a weak one from succeeding layers. Analysis by absorption in an independent layer of sodium vapour shows that the superficial emission is more absorbable, and therefore nearer the centre of the D lines. The breadth of the D lines in superficial resonance has been estimated by interferometer methods. It is found to correspond with the breadth conditioned by the Doppler-effect, on the assumption that the luminous centre is the Na atom. Polarisation could not be detected in the ultra-violet resonance radiation, though in accordance with previous observers it was readily observed in D resonance radiation.

The paper gives a general discussion of the whole subject. A. W.

382. *The Radiating Potentials of Nitrogen.* **H. D. Smith.** (Phys. Rev. 14. pp. 409–426, Nov., 1919.)—1. A formula is derived by which accurate corrections allowing for the distribution of velocities of the impacting electrons may be applied to the observed values of the radiating potentials.

2. Measurements on nitrogen revealed:

(*a*) A very strong effect at 8·29 ± 0·04 volts.
(*b*) A very doubtful effect at 7·3 volts.
(*c*) An effect appearing only at lower pressures but strongly at 6·29 ± 0·06 volts.

3. These results are explained as follows:

(*a*) The wave-length λ corresponding to 8·29 ± 0·04 is 1490·7 ± 10, and this effect is, therefore, identified with the double found by Lyman at 1492·8 and 1494·8.
(*b*) This gives λ = 1700 and may be identified with the second doublet 1742·7 and 1745·3 attributed to nitrogen but by some thought due to silicon.
(*c*) The value λ = 1965 ± 20 from 6·29 ± 0·06 volts is taken to correspond to the beginning of the band spectrum at 1870·9. The discrepancy is attributed to the presence of nitrous oxide.

According to another theory the effect at 6·29 is considered due to lines in the region 2000–3000 Å.U. coming from neutral atoms. The value 6·29 in this case is taken as the speed necessary before the electrons can split up the molecules.

4. From 3 (*a*) assuming line spectra to come from atoms, we have as an upper limit to the heat of dissociation of a gramme molecule of nitrogen 190,000 cals.

From the second theory in 3 (*b*) we have as a possible actual value for this heat of dissociation 145,000 cals.

5. Qualitative evidence was obtained supporting Davis and Goucher's discovery of true ionisation in the neighbourhood of 18 volts. AUTHOR.

383. *Energy Distribution in Spectra.* **J. W. Nicholson.** (Chem. News, 119. pp. 217–218, Nov. 7, and pp. 226–227, Nov. 14, 1919. Abstract of lecture delivered at the Roy. Inst., May, 1919.)

384. *On the Spectrum of X-rays from an Aluminium Target.* **W. Duane and T. Shimizu.** (Phys. Rev. 14. pp. 389–398, Nov., 1919. Paper read

before the Am. Phys. Soc., March, 1919.)—*Aluminium Spectrum*: The object of the research has been to investigate the question whether or not the frequencies of the K series are the highest X-ray frequencies characteristic of a chemical element. Several investigators have found experimental evidence, which they interpret as indicating the existence of characteristic emission or absorption of frequency higher than those in the K series. For aluminium the wave-lengths corresponding to these frequencies are stated to be $0{\cdot}37 \times 10^{-8}$ cm. and $0{\cdot}49 \times 10^{-8}$ cm. The present authors have examined the emission spectrum of Al between the wave-lengths $0{\cdot}1820 \times 10^{-8}$ cm. and $1{\cdot}259 \times 10^{-8}$ cm. Four small peaks occur on the curves, indicating characteristic radiation at wave-lengths $0{\cdot}622 \times 10^{-8}$ cm., $0{\cdot}705 \times 10^{-8}$ cm., $0{\cdot}975 \times 10^{-8}$ cm., and $1{\cdot}18 \times 10^{-8}$ cm. The first two belong to the K series of molybdenum, and undoubtedly come from the metallic molybdenum in the Coolidge kathode in the X-ray tube. The last two belong to the L series of lead, and undoubtedly come from the lead screens containing the slits through which the X-rays passed before they reached the X-ray spectrometer.

No other peaks appear on the curve, and this leads to the conclusion that, within the range examined, Al has no emission lines the intensities of which amount to as much as 2 % of the general radiation in the neighbourhood.

AUTHORS.

385. *Grating Space of Calcite and its Influence on the Determination of* "h." **Ledoux-Lebard** and **A. Dauvillier.** (Comptes Rendus, 169. pp. 965–967, Nov. 24, 1919.)—On the basis of certain observations given in the paper, the authors conclude that the most probable value of d_ϕ for calcite is

$$d_\phi = 3{\cdot}02825 \pm 0{\cdot}00225 \times 10^{-8} \text{ cm.}$$

Employing the experimental results of Blake and Duane on X-ray emission, and making certain corrections, the authors give as a probable value of h

$$h = 6{\cdot}5564 \pm 0{\cdot}015 \times 10^{-27}$$

A. B. W.

386. *X-ray Spectrum of Tungsten.* **M. de Broglie.** (Comptes Rendus, 169. pp. 962–965, Nov. 24, 1919.)—Remarks relating to the experimental work of Siegbahn and Overn on this subject.

A simple method is described for avoiding troubles due to fogging of the photographic film in taking X-ray spectrograms. With the precaution suggested, it is possible to bring out more clearly very feeble lines, which might otherwise be missed. A. B. W.

387. *Scattering of X- and γ-rays by Rings of Electrons. A Crucial Test of the Electron Ring Theory of Atoms.* **G. A. Schott.** (Roy. Soc., Proc. 96. pp. 395–423, Jan. 2, 1920.)—"It is generally admitted that the electron ring theory of atoms, based on the classical electrodynamics and mechanics, does not explain certain results of recent investigations respecting thermal radiation, photoelectric emissions, transformations between corpuscular and X-ray energies, and spectrum series. All these phenomena involve the interaction of radiation in one form or another, not merely with electrons, but also with matter, not so much with matter in bulk as with material atoms, and the failure of the electron ring theory to account for this may after all be due rather to our ignorance of atomic structure than to defects in the fundamental principles of the theory itself. Moreover the hypotheses proposed for the explanation of the phenomena in question, such as the quantum hypo-

thesis, themselves fail to account for other phenomena, such as interference, diffraction and polarisation, which are so familiar to us that the necessity of explaining them afresh is apt to be overlooked when a new theory is introduced. In view of the present unsatisfactory state of our theories and the indecisive character of our experimental knowledge, a crucial experimental test of the electron ring theory is very much to be desired, especially one involving as little knowledge of atomic structure as possible. The object of the present investigation is to show that the phenomena of the scattering of X- and γ-rays by matter, affords a test of this kind, and, moreover, if the issue of the test be favourable, supplies a means of investigating experimentally the arrangement of the electrons in, at any rate, the lighter atoms. By scattering is meant the redistribution in space, without change of frequency, of a portion of the radiation incident on matter. For our purpose any radiation of altered frequency, generated by processes akin to fluorescence or phosphorescence, must be carefully distinguished from scattered radiation."

With this introduction the author states mathematically his views of a complete theory of scattering of X- and γ-rays by matter. He points out the reasons for the future of the "pulse theory" of J. J. Thomson—replacing this theory by another based on the wave theory, which has superseded the pulse theory. In the mathematical discussion three theories are considered: (1) Simple Pulse Theory; (2) Electron Ring Theory; (3) The Ring Electron Theory. The results of most importance for a comparison of these theories are summarised in the following table, where the total scattering is expressed, for convenience, in terms of S_H, or $8\pi e^4/3c^4m^2$, the total scattering of the hydrogen atom on the simple pulse theory, as a unit. N denotes the atomic number, taken to be the total number of mobile electrons in the atom, whether ring electrons or electrons of the usual type. For the electron ring theory n, as before, denotes the number of electrons of the usual type in any one ring, and the sign of summation refers to the several rings, so that $N = \Sigma n$.

R

Theory.	Maximum Total Scattering (Long Waves).	Maximum Total Scattering (Short Waves).	Maximum Asymmetry.
Simple pulse	N_1 for all	wave-lengths	0
Electron ring	Σn^2	N	Increasing as n increases
Ring electron	N	0	Always large

The corresponding values of the mass scattering coefficients relative to hydrogen are obtained from those of the relative atomic scattering coefficients given in the second and third columns by dividing by A the atomic weight of the element considered.

The table indicates crucial tests for deciding between the several theories. For example, for hydrogen we take $N = n = 1$; according to the simple pulse and electron ring theories, the total scattering has the same value, unity, for all wave-lengths, and there is no asymmetry; according to the ring electron theory, however, the total scattering only has the value unity for long waves and diminishes to zero for short ones, whilst the max. asymmetry is as large as that found by Ishino for Al, Fe, and Pb, but probably occurs at a longer wave-length. If the scattering from hydrogen, whether gas under pressure or liquid, can be observed at all, even quite rough measurements should be decisive for or against the ring electron theory, but could not decide between the other two theories. Similarly for helium $N = n = 2$.

Unfortunately, the experimental data available for comparison are few and contradictory. A. B. W.

RADIO-ACTIVITY.

388. *Radio-activity of Uranium.* **C. Staehling.** (Comptes Rendus, 169. pp. 1036–1039, Dec. 1, 1919.)—The author describes some interesting experiments relating to the radio-activity of the "black" and "green" oxides of uranium. These oxides, in addition to a penetrating radiation, emit a very soft type of radiation which forms the basis of the present investigation. It has been demonstrated consistently, that even when the black oxide U_3O_8 and the green oxide U_3O_8 are prepared from the same sample of uranyl nitrate by the direct method of calcination, the soft radiation is always greater from the black oxide than from the green; the penetrating radiation being the same in the two cases. If the less active green oxide be re-converted into nitrate and subsequently converted into black oxide, it is always found to have increased in activity [as measured by the soft (or total) radiation]. Other experiments of the nature are described, with substantially the same result. Experiments are in progress to elucidate the mystery. (Erratum, *Ibid.*, p. 1128, Dec. 8, 1919.) A. B. W.

389. *Radio-activity and Gravitation.* **E. Rutherford** and **A. H. Compton.** (Nature, 104. p. 412, Dec. 25, 1919.)—In response to a suggestion by Schuster, the authors developed an accurate method of testing the rate of decay of radium emanations over a period of about 100 days in order to compare this rate at suitable portions of the earth's surface. The war preventing this, the effect was observed of submitting the radio-active substance to centrifugal acceleration, which according to Einstein's theory is in no sense different from gravitational, of more than 20,000 times the amount of gravity. The change, if any, was certainly less than one part in a thousand, which is not in disaccord with Donnan's conclusion [see Abs. 402 (1920)], in that his relation predicts an effect very much smaller than could be detected by experiments of this character. G. W. DE T.

390. *Radio-activity of Water from Bagnoles-de-l'Orne.* **P. Loisel.** (Comptes Rendus, 169. pp. 791–792, Nov. 3, 1919.)—The radio-activity of the gases from this source was studied in 1904 by Curie and Laborde. They found, per litre of gas, a quantity of emanation equivalent to 0·17 mgm.-minutes of $RaBr_2$, or 0·0118 micro-curies per litre. In 1907 Moureu found in gas collected from the same source, under similar conditions, a quantity of emanation equivalent to 0·0024 micro-curies per litre. The author has recently made fresh determinations and attempts to explain the cause of the variations referred to above. He has examined carefully the radium content of the water itself, and in this case also observes a variation from 22×10^{-12} gm. to 109×10^{-12} gm. per litre, giving a mean value of 68×10^{-12} gm. per litre.
A. B. W.

391. *Radio-active Luminous Compounds.* **Bahr.** (Elekt. Zeits. 40. pp. 299–301; Disc., 301–302, June 18, 1919. Paper read before the Deut. Beleuchtungstechn. Gesell.)—A general description of the different forms of self-luminous materials with particular reference to those depending on the use of radio-active substances. J. W. T. W.

HEAT.

392. *Low-Temperature Studies. Permeability to Heat Rays.* **J. Dewar.** (Engineering, 109. pp. 122–128, Jan. 23, 1920. Discourse delivered at the Roy. Inst., Jan. 16, 1920.)—The permeability of many substances to dark radiations at the temperature of liquid oxygen is studied with the aid of a new thermoscope which is a pressure gauge admitting of determining temperature-rises of 0·001 deg. C. The apparatus consists of a small box, built up of a brass ring, 4 cm. in diam., over which a fine rubber membrane is stretched; underneath the membrane is about 1 gm. of charcoal, supported on chiffon. Above the membrane is a stage of the shape of a flat ring on which the material to be tested is placed; the stage is covered by a lid which has to be raised by a chain to admit the radiation. The whole apparatus is immersed in liquid oxygen, contained in a vertical Dewar vessel, which is jacketed with liquid air. The radiation passing down the vessel has to penetrate through several cm. of liquid oxygen before reaching the substance, membrane and the charcoal, from which it liberates some oxygen; the pressure of this oxygen is measured in a U-tube. When the thermoscope is mounted in the gaseous oxygen (above the liquid), the equilibrium conditions, which are reached within 20 seconds in the liquid, are not so quickly established. A great many materials have been examined, solids (quartz, salts, ice) in plates or powdered and compressed, also rolled out (AgCl), liquids frozen or in thin films, especially also organic compounds, in order to study the permeability of derivatives and isomers; the introduction of nitrogenous radicals generally lowers the permeability (ammonium bromide is also less transparent than rock salt), whilst the introduction of halogens sometimes tends to increase the transparency. A correction for the loss of radiation by reflection is made with the aid of Fresnel's law. In the preliminary investigation it was ascertained that fine rubber membranes become stronger in liquid air and practically impermeable to gases, while they remain transparent to dark radiations. H. B.

393. *Thermal Conductivity of Solid Insulators.* **W. M. Thornton.** (Phil. Mag. 38. pp. 705–707, Dec., 1919.)—The object of the present note is to direct attention to some relations between the heat conductivity (k), the elasticity (E), the density (ρ) and the velocity of sound (v) in non-metallic solids, which must be explained by any theory of conduction. A table is given in which it is shown that over a wide range of solids the relations $k = E\rho = v\rho^2$ agree with surprising accuracy. This indicates some fundamental process beneath these phenomena. "On the electron theory of matter, mechanical forces are eventually expressed in terms of electric charge or movement of charge. Resistance to compression is a repulsion between the structural elements of matter, possibly of the nature of an electrostatic repulsion between electrons which form the outer frame of atoms. The sudden compression of a sound-wave then gives rise to electrostatic forces of recoil and the velocity of sound is the rate of uniform transmission of these through a loaded ether. On the other hand, the heat energy of irregular motion may be considered as that of alternating atomic currents attracting and repelling at random and so transmitting the motion electro-

magnetically. It is possible to extend this to a general consideration of thermal conductivity in insulators as an electromagnetic phenomenon."

The chief practical qualification of a material as a heat insulator is that it should be light and inelastic. T. H.

394. *Origin of Radiation in Gaseous Explosions.* **W. T. David.** (Phil. Mag. 38. pp. 492–494, Oct., 1919.)—In a previous paper [Abs. 1002 (1918)] the author came to the conclusion that it was difficult to account for the large emission during cooling, unless the gaseous mixture was capable of emitting radiation in virtue of its temperature, but stated that there was no experimental evidence of a gas emitting radiation in virtue of its temperature alone. Further considerations of his own experiments on mixtures of H and air [Abs. 1708 (1911)], however, have led him to the conclusion that these afford fairly conclusive evidence that water-vapour has a pure temperature emission. CO_2 and H_2O molecules also are capable of vibrations of the same order of frequency, and his experiments have shown no difference in their behaviour in gaseous explosions except the more powerful radiation from the former, and this was to be expected from the respective infra-red absorption spectra. He is now of opinion that the direct emission of short-wavelength radiation is of chemical origin but that low-frequency vibrations, of length 2 ft. and over, are due to temperature, and that these are damped partly by emitting radiation, but mainly by a transference during molecular collisions from it to translational and rotational forms of energy. G. W. de T.

395. *Standardised Method for the Determination of Solidification Points, especially of Naphthalene and Paraffin.* **R. M. Wilhelm** and **J. L. Finkelstein.** (Bureau of Standards, Bull. 15. pp. 185–197 [Sci. Papers, No. 340], 1919.)—This method, which is an adaptation of a well-known one, was recommended at a conference of Bureau of Standards and United States customs officials and was adopted by the U.S. Customs Service for the determination of the solidification point of naphthalene. L. H. W.

396. *Report of Pyrometer Committee of National Research Council.* **G. K. Burgess.** (Am. Inst. Mining Eng., Bull. No. 153. pp. 2271–2300, Sept. 1919.)—The Pyrometer Committee was formed in 1918 for the purpose of developing a pyrometric method suitable for open-hearth steel practice. The present paper gives at great length the results of various experiments on the determination of temperatures of liquid steel by special methods. The greatest difficulty in producing a suitable pyrometer is the refractory material which must possess sufficient mechanical strength, combined with suitable chemical and thermal properties. It must withstand the corrosive action of slags, hot gases, etc. It must not crack on sudden heating or cooling; it must be capable of being manufactured into closed-end tubes and must be of sufficient thermal conductivity to allow the interior rapidly to assume the temperature of the region into which it is thrust.

The first piece of work was the investigation of the method suggested by R. C. Drinker for determining the temperature of the metal bath by a modification of the spoon method. A special crucible was devised for the purpose, and is illustrated in the original paper. There are, however, several difficult conditions to be fulfilled for the method to be successful, and consequently it was discarded. A long series of experiments was then undertaken with refractory tubes and the optical pyrometer. It appeared that a fire-clay insulator with a graphite tip might form the basis of a suitable piece of apparatus. Drawings are given in the original paper of the way in which the refractory tube and tip were made up. A wrought-iron tube was used to give the necessary strength and was surrounded with a refractory sleeve. In operation, the hot end was viewed with the optical pyrometer, by looking down the tube, but observations were often difficult owing to the fact that a certain amount of smoke was produced within the tube. Consequently it was necessary to ventilate it so as to force the smoke out. The conclusion was reached that open-hearth steel temperatures can be taken with such a tube, but that it is difficult to handle the tube and to protect the operators. It is thought that the difficulty with the smoke from the graphite may be eliminated by having a clay tip, if that should prove satisfactory in other respects.

Much more satisfactory results were obtained by using Acheson graphite. No smoke is then produced and it has plenty of strength; moreover, the slag does not stick to it. Steel temperatures might be taken either by sighting direct on the tip or by sighting down the tube. The pyrometers so made were not used for any considerable life.

A large number of observations are reproduced in the original paper.

W. R. C.

397. *Determination of Ignition-Temperatures by the Soap-bubble Method.* **A. G. White** and **T. W. Price.** (Chem. Soc., J. Trans. 115. pp. 1248–1264, Nov., 1919.)—Testing the method of McDavid [Abs. 76 (1918)], by experiments with mixtures of ether, benzene, light petroleums, and hydrogen with air, the authors find that consistent results are only obtained under certain conditions. The results are influenced by several factors, such as the physical state of the hot surface and its material, which is affected not only by the wire of the coil (platinum, eureka, nichrome), but even the addition of small quantities of the salt used for standardising the hot body. Draughts and the room temperature are other factors; when the coil is brought into the gas mixture, the combustible portion in it is at once removed by surface combustion; already on the approach of the hot body, ether volatilises through the soap bubble; for this reason a mixture of amyl acetate and air, made up at 20°, could not be ignited at all by the method, and the ignition temperatures found for a 12 % ether-air mixture ranged from 859 to 1085°. The method is not strictly trustworthy even for comparative purposes, but might be radically improved; it is suggested that the bubble might be shielded from radiation.

H. B.

398. *Ignition of Mixtures of Air with Ether, Alcohol, Acetone in Contact with Hot Surfaces.* **A. G. White** and **T. W. Price.** (Chem. Soc., J. Trans. 115. pp. 1462–1505, Dec., 1919.)—The investigation was begun on account of the large number of fires occuring in the solvent-recovery stoves in which cordite is dried, especially when ether-alcohol serves as solvent. Since ether is known to burn at low temperature with a pale phosphorescent cool flame, which may rapidly turn hot, and since the soap-bubble method of McDavid [Abs. 76 (1918) and preceding Abs.] proved unsuitable, the authors determined the sub-ignition temperature, at which combination becomes self-supporting, in tubes heated to different temperatures, eliminating the effect of surface action by experimenting with tubes of different sizes. The glass tube is placed within a tubular electric surface, evacuated, and then charged with the gas mixture by turning the cock of a reservoir admitting the mixture through glass tubing (leads) of various lengths and diameters. It was found that a lead of 1 mm. diam. would give a sub-ignition temperature of about 200°,

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whilst with 5-mm. leads ignition occurred at 50°; when a cock of 1·5 cm. bore was used, the mere sudden turning of the cock caused ignition at 16·5°. The ignition seemed to be due to the stoppage of the gas rushing into the exhausted tube (shock ignition). By reducing the length of the leads, and more still by letting the tube project from the furnace, too ready ignition was prevented, and concordant results were obtained with tubes of 2·5, 4, or 5·5 cm. diam., 100 or 180 cm. long, and leads of 8 mm.; the observation of the ignition was, however, difficult. As the ether in the mixture increases from 1 to 2 %, the sub-ignition temperature drops rapidly from about 480° to 200°. Alcohol-air mixture of 5 % ignited at 485°; ether-alcohol-air mixtures of 2 : 4 : 94 % at 255°, of 1 : 4 : 95 % at 455°. Acetone-air mixtures ignited at about 500°. Lining the glass tube with tubes of copper, iron, lead, zinc, hardly changed the temperatures; the explosions were, however, always more violent in the presence of metals. For very small gas velocities (up to 18 cm./sec.) increase of velocity raised the ignition temperature of ether-air; in works the gas or vapour velocities would be much larger. The presence of glyceryl trinitrate did not affect the flames and ignition temperature notably, but the presence of peroxides gave very fierce flames and explosions. The propagation of the flames was also studied in tubes of glass and iron, and le Chatelier's rule only partly confirmed. Increase of temperature raised the upper limit for propagation, reduction of pressure narrowed the limits, while increased gas velocity widened the limits. Sparks of steel to steel, emery to steel, pyrites to steel, did not inflame any of the mixtures; ferro-cerium sparks did.

H. B.

399. *Flame Propagation in Complex Gaseous Mixtures.* **W. Payman.** (Chem. Soc., J. Trans. 115. pp. 1436–1462, Dec., 1919.)—I. *Limit Mixtures and Uniform Flame Movement.* In a limit mixture the heat developed by a layer on burning is just sufficient to raise the contiguous layer of gas to ignition temperature [see Abs. 460, 461 (1919)]. Limit mixtures should remain limit mixtures when themselves mixed; this rule is investigated with respect to variations in the inert gas proportion (nitrogen). In the case of methane when mixed with atmospheres containing 50, 60, 100 % of oxygen, it was observed that the upper-limit flame, generally olive-green, had the appearance and smell of a smouldering tallow-candle, and that the deposition of carbon from such flames, noticed by Bone, varies with the initial pressure. As regards influence of the point of ignition (in globes or tubes), the lower limit of inflammability of methane is less in oxygen than in air for upward and horizontal propagation, but for downward propagation the order is reversed; yet in atmospheres containing less oxygen than air comparatively more methane is required to form a limit mixture. This is partly due to convection currents, and as they cannot accurately be allowed for, the limits of inflammability of a gas cannot be calculated from its thermal constants. The displacement of the range of inflammability also shows in the relative proportion of H and CO in the combustion products. Experiments on the uniform movement of flame in limiting mixtures of methane, ethane, propane, etc., with air in a tube, 2·5 cm. in diam., show that these speeds approach a constant value, irrespective of the nature of the inflammable gas.

II. *Uniform Movement in Mixtures of Air and Paraffin Hydrocarbons.* This rule, that the speeds tend to a constant value, is not restricted to limit mixtures, but holds in general for mixtures containing excess of either combustible gas or of oxygen; this is shown for the paraffin hydrocarbons (max. speed about 82 cm./sec.), for mixtures of pentane and methane (speed 40 cm.), and even in the case when a mixture of pentane and hydrogen ($8C_5H_{12} + 2H_2$) is substituted for propane, though the max. speed of the individual hydrogen gas is very high, reaching 485 cm. The max. speed of uniform flame movement can hence be calculated.

III. *Uniform Movement in Mixtures of Air with Mixtures of Methane, Hydrogen, and Carbon Monoxide and with Industrial Gases.* Mixtures of air and CO have a max. speed of flame for 45 to 50 % CO though complete combustion is observed with 29 %. In industrial gases water-vapour is present, but the author considers the vapour effect on the speed similar to that of hydrogen. In coal gas and producer gas he also regards the cooling and retarding effects of air and of nitrogen as practically the same, and neglects the influence of any CO_2. On the whole his calculated and observed figures (experiments in tubes of 2·5 cm.) are in agreement. H. B.

400. *Saturation Pressure of Water-Vapour.* **P. Schreiber.** (Phys. Zeits. 20. pp. 521–523, Nov. 15, 1919.)—Proposes the formula $\log s = p + q \log T + \log f(T)$ for the saturation pressure s at temperature T, p and q having respectively the values $-42·67$ and $+17·8$, while $\log f(T) = -0·0000494 (T-298)^2$, T being expressed in degrees (K.) and s in mm. of mercury.

J. W. T. W.

401. *Comparison of Explosion Temperatures Calculated from Specific Heats with those Calculated from Explosive Pressures.* **H. Muraour.** (Comptes Rendus, 169. pp. 723–726, Oct. 27, 1919.)—Explosion temperatures may be calculated by two different methods: (1) based on the theoretical equation of decomposition and the specific heats of gases; (2) based on pressure measurements and the gaseous volume evolved by the explosion. It has been generally accepted from the investigations of Mallard and le Chatelier, that both methods lead to neighbouring though not identical values. The following considerations have induced the present author to re-examine the problem:—(i) The pressures utilised in Mallard and le Chatelier's work were obtained by more primitive methods than those now available. (ii) Doubts have been raised as to the real value of the pressures indicated in the manometric table, new tables having been proposed which differ by about 20 %. (iii) Finally, while the variation of the specific heat of the gas with temperature is well established, yet the real values of the specific heats at high temperatures have not been fixed with certainty. These varied considerations have led the author to compare explosion temperatures calculated (I) by means of the specific heats of Mallard and le Chatelier and Sarrau; (II) by specific heats proposed by Schreber; (III) from the table of manometric pressures; (IV) from the new pressure tables C. The experimental tests have been made upon a mixture of tolite and ammonium nitrate, and upon mixtures with increasing amounts of ammonium nitrate added to lower the temperature. The simplified Clausius equation, $p = RT/(v-a)$ has been assumed to be true, while the co-volume has been taken equal to 1/1000 of the specific volume, as per ordinary practice, since Berthelot has shown this to be valid for gaseous explosions. The data from Mallard and le Chatelier and Sarrau have been found appreciably higher than data based on the manometric pressure table. Towards 1500°, the temperatures of Mallard, etc., are identical with those based on the revised table C. Between 1500–1700° C. the calculations based on the older results give temperatures which are certainly below the actual values; *e.g.*, whereas calculation gave 1486° C. for one experiment, yet partial fusion of a platinum wire occured for which 1750° C. would be required. Temperatures calculated from Schreber's specific heats between 1800° and 2700°, are in satisfactory accord with those based on table C. H. H. Ho.

402. *Heat of Reaction and Gravitational Field.* **F. G. Donnan.** (Nature, 104. pp. 392–393, Dec. 18, 1919.)—Let m_1, m_2, be the masses of the initial and final states of a chemical system and Q the heat evolved, say, at constant t and p, and at gravitational potential Z. Consider the isothermal cycle: State 1 to state 2 at Z. State 2 at Z to state 2 at $Z + \delta Z$. State 2 to state 1 at $Z + \delta Z$. State 1 at $Z + \delta Z$ to state 1 at Z. Equating the total energy change to zero, $(\partial Q/\partial Z)^{p,t} = m_1 - m_2$. For ordinary reactions, experiment shows $m_1 - m_2$ to be very small, if not zero. But by the theory of relativity, if the reaction be exothermic, $m_1 > m_2$, while if endothermic, $m_1 < m_2$, and therefore $\partial Q/\partial Z$ is positive in the former case and negative in the latter. If the energy theory be applicable to the highly exenergic radio-active changes, it will follow that the energy given out in such changes must be greater in a strong than in a weak gravitational field. G. W. DE T.

403. *Latent Heat and Surface Energy.* II. **D. L. Hammick.** (Phil. Mag. 39. pp. 32–46, Jan., 1920.)—(1) On the assumption that van der Waals' a varies with temperature, a relation is derived between a_T, surface energy, and molecular volume, $a_T = 6\rho V/d$. This equation is valid only at low temperatures. By assuming that a_T diminishes linearly with temperature to the critical value a_c, latent heats are calculated by the use of Bakker's equation for several liquids.

(2) Recognition of the fact that the ratio a/a_c at the boiling-point is the same for many liquids results in the derivation of Trouton's Constant.

(3) Walden's empirical relationships between surface energy and latent heats and the Ramsay-Eötvös law are deduced. AUTHOR.

404. *Heat Distribution on a Radiating Plane.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 1. pp. 308–318, Nov.–Dec., 1919.)—The temperature θ of a plane sheet, which is radiating heat into an external medium at 0° C., and keeping in a stationary state, satisfies as a function of the coordinates x, y in its plane, $\partial^2\theta/\partial x^2 + \partial^2\theta/\partial y^2 = k^2\theta$, where k^2 denotes surface conductivity divided by internal conductivity. Assuming the sources of heat to be given, or the temperature on some boundary to be prescribed, the author considers the distribution of the temperature when the straight lines form the boundaries. The paper is mathematical throughout. H. H. Ho.

405. *Radiation Emitted in Gaseous Explosions.* **W. T. David.** (Phil. Mag. 39. pp. 66–83 and 84–95, Jan., 1920.)—In the first of these papers the author develops approximate formulæ on the basis of experimental results obtained with apparatus previously described in detail in an earlier paper [see Abs. 894 (1920); also Abs. 1412 and 1528 (1919)], by means of which the emission of radiation during explosion and subsequent cooling of mixtures of coal gas and air of various strengths was confirmed from the pressure time-curves for these mixtures. Factors are introduced for the approximate determination when the mixture is contained in a cylinder of dimensions different from those of the experimental vessel, and when the density is other than atmospheric. They can only be relied on to give results correct within 10 to 20 %, but being the first attempt at such formu-

lation, the author suggests that they may serve as a basis for gas-engine calculations.

In the second paper the author gives results of experimental analyses of the radiation emitted during explosion and subsequent cooling of mixtures of coal gas and air and of H and air. He finds that: (1) The ratio of the energy in the 2·8 μ radiation emitted, to that in the radiation of longer wave-length, decreases with the temperature; (2) the 2·8 μ radiation decreases rapidly at the absolute temperature of about 1200° C., and becomes negligible at 1000°; (3) radiation of longer wave-length is emitted even when the absolute temperature has fallen to 900° absolute, but the emission is then small; (4) the ratio of the energy in the 2·8 μ radiation to that in the 4·4 μ radiation in coal gas and air appears to depend to some extent on the strength of the mixture as well as on the temperature. The proportion of the heat of combustion of H and air mixtures between 10 % and 25·4% decreases rapidly with the mixture strength. In coal gas and air mixtures the variation in this proportion is small between the mixture limits of 9·8 and 15 %. The theoretical conclusions drawn are that: (1) The radiation emitted during the cooling of both mixtures after explosion is largely thermal; (2) the transfer of energy between the vibratory degrees of freedom corresponding to radiation 2·8 μ and the other degrees of freedom of the molecules is comparatively slow at 1200° abs., and practically ceases at 1000°; but transfer of energy to or from the vibratory degrees of freedom corresponding to greater wave-length continues at least down to the mean temperature of 900° abs.; (3) the greater the violence of combustion the greater the ratio of the energy in those degrees of freedom corresponding to radiation 2·8 μ, to that in the degrees of freedom corresponding to radiation of greater wave-length. The author considers that there are grounds for the following generalised statement: The intramolecular energy acquired on combustion by the freshly formed molecules of CO_2 and H_2O is not equally partitioned over the various internal degrees of freedom possessed by these molecules. When the combustion is gentle the intramolecular energy is concentrated in the rotational degrees of freedom, and in such very low-frequency vibration as the molecules may be capable of. With more violent combustion the higher-frequency vibrations share in this energy, and it is possible that during combustion of extreme violence equi-partitioning of energy amongst all the internal degrees of freedom of the molecule may be momentarily approached. The author suggests that such a theory would seem to explain many phenomena of the explosion period, including the pre-pressure period during which a considerable volume of inflammation takes place. G. W. DE T.

406. *An Amendment to the Equation of State for a Fluid.* **E. Ariès.** (Comptes Rendus, 169. pp. 1140–1143, Dec. 15, 1919.)—Reference is made to the author's previous work on this subject [see Abs. 1078 (1919)]. The equation then found was $p = RT/(v - a) - \phi/(v + \beta)^2$, in which ϕ, a, and β are three functions of the temperature, the first being of the form $\phi = K/T^n$. It has been shown that the exponent n may deviate appreciably from its average value at high temperatures. The result is that the formulæ deduced from the equation of state may lose their rigidity at temperatures neighbouring the critical, although it has been possible to establish a satisfactory equation for propyl acetate and ethyl formate. Ether and chlorine, among other substances, have proved exceptions in that no fixed value has been found for n. The function ϕ is now examined, and it is found that at

absolute zero ϕ becomes infinite, as also the internal pressure as a consequence. This is hardly compatible with kinetic theory. To amend the equation of state, ϕ is first allowed to be completely indeterminate. It is then found more valid to express the exponent n as a function of the temperature, but so that the functions ϕ and n are connected by the relation $\phi = \mathrm{K}/\mathrm{T}^n$. Most of the previous formulæ are then shown to preserve their original forms. The formula giving the heat of vaporisation is only slightly modified and becomes :

$$\mathrm{L}/\mathrm{RT} = (y_1 - y_2)\left[\frac{2 + n + \mathrm{T} \log \tau \partial n/\partial \tau}{8} \mathrm{Z} + \frac{\partial/\partial \tau \log z}{y_1 y_2}\right]$$

H. H. Ho.

407. *Quanta Theories and Adiabatic Hypotheses.* **K. Försterling.** (Ann. d. Physik, 60. 7. pp. 678–684, Dec. 9, 1919.)—The quanta theories of Planck and Sommerfeld are each based upon statistical mechanics, whereby the dimensions of the volume elements of like probability are determined by the quantum condition, according to the special formulation of Sommerfeld : $\int\int dp_i dq_i = h$ or $\int q_i dp_i = mh$, $m = 1, 2, 3 \ldots$, where p denotes the generalised coordinates and q the impulses. Difficulties arise which demand a wider choice of coordinates. The author now attempts to solve the problem, using the principle of least action and the identity $\Sigma \int q_k dp_k = \int q_k \frac{dp_k}{dt} dt = 2 \int \mathrm{T} dt$, where T denotes the kinetic energy. Section 2 deals with the formulation of the quantum condition with reference to the Ehrenfest adiabatic hypothesis. Section 3 considers motions under special quanta conditions, since Sommerfeld's condition in general does not include adiabatic changes of state, and these special conditions are formulated in section 4. In section 5, the Bohr frequency condition is considered. Section 6 contains a summary of the paper, together with hydrodynamic analogies. The basis for the considerations advanced is the equation, $\delta\phi = \frac{1.}{(t_2 - t_1)}\left[2\delta \int^{2} \mathrm{T} dt - \Big| \Sigma q_k \delta p_k \Big|_{1}^{2}\right]$, obtained by comparing a system which involves the constant energy E in the time $(t_2 - t_1)$ with a neighbouring system of energy $(\mathrm{E} \times \delta\mathrm{E})$ in the time $(t_2 + \delta t_2) - (t_1 + \delta t_1)$. A mechanical change of the system whereby $\delta\phi = 0$, is termed adiabatic. The above equation is used in conjunction with the Ehrenfest adiabatic hypothesis. It is shown that the Sommerfeld quantum hypothesis is, in general, not compatible with the adiabatic hypothesis, and hardly constitutes the most general form of the quantum theory. It is concluded that the Sommerfeld hypothesis can only be true for definite coordinate systems, and possesses a highly improbable form for so general a physical principle. The author reverses the problem into finding the quanta conditions, assuming the adiabatic hypothesis, for the validity of the Sommerfeld hypothesis, and as a result arrives at the Schwarzschild-Epstein rule.

The application of the above equation to the passage of an electron from one quantum orbit to another in the Bohr atomic model leads directly to the Bohr frequency condition for simple structures like hydrogen. With complex atoms deviations may occur, probably due to the adiabatic oscillations, and the author opines that their elucidation may perhaps be found in the study of Röntgen rays. A difficulty for the physical comprehension of the Bohr radiation is apparently the failure of the experiment to make a corresponding periodic motion of the electron responsible for the emission of the periodic ether wave. An analogous phenomenon in hydrodynamics can be quoted, in that when a body moves uniformly through a liquid there arises behind it a periodic eddy arrangement which has been exhaustively investigated by Karman. Here, therefore, are periodic oscillations caused by non-periodic motion analogous to the Bohr emission. The adiabatic wave, on the other hand, has analogy in the production of vibrations by a tuning-fork, where in both cases the motion and the oscillation produced have the same period. H. H. Ho.

408. *Significance of the Chemical Constant and its Relation to the Behaviour of Gases at Low Temperatures.* **F. A. Lindemann.** (Phil. Mag. 39. pp. 21–25, Jan., 1920.)—The general equation for the vapour pressure of a solid, derived by integrating the Clausius-Clapeyron equation is of the form:

$$\log p = \int^{T} \lambda/RT^2 \,.\, dT + C = \int^{T} \frac{\lambda_0 - \int_0^T c_p dT + \int_0^T C_p dT}{RT^2} dT + C.$$

Here λ is the latent heat, λ_0 the same at the absolute zero, c_p and C_p the molecular heats of solid and gas at constant pressure, R the gas constant, and C the chemical constant. The object of the present paper is to examine the question of the dimensions of C somewhat more in detail than is usually done, since it may be shown that this question is intimately bound up with the problem of the degradation of perfect gases. The author shows that the evidence of the chemical constants seems to be against the degradation theory if the above equation is accepted, and, moreover, the physical significance of the chemical constant appears in quite a new light when examined on these lines. In the text-books two different statements are found, namely: that the chemical constant has the dimensions of the logarithm of a pressure, and that it has the dimensions of the logarithm of a pressure divided by a temperature to the power 5/2. The first statement, which at first sight appears to be justified by the fact that $\lambda/RT^2 \,.\, dT$ is a pure number, really entails the assumption that the atomic heat of the gas becomes equal to that of the solid at the absolute zero. The second view is arrived at by assuming the gas laws to hold down to the lowest temperatures. It is now shown that the chemical constant has the dimensions of the logarithm of a pressure if the atomic heat of monatomic gases becomes zero at the absolute zero. In this case it should be of the form $K + (3/2) \log A + (5/2) \log \theta$, where θ is a characteristic constant of the substance. It is also shown to have dimensions of the logarithm of a pressure divided by a temperature to the power 5/2 if the atomic heat of a monatomic gas remains (5/2)R down to the absolute zero. In this case it should be of the form $K + (3/2) \log A$. Experimental determinations show that the latter form is true within the limits of error. It follows either that θ is very nearly equal to 1 deg. for all substances, which seems improbable, or that the atomic heat remains constant down to the lowest temperatures. Finally, it is shown that the chemical constant may be eliminated and the vapour pressure expressed in terms of the pressure of complete radiation. It is therefore suggested that the chemical constant may express the interaction of matter and complete radiation, rather than requiring that a gas can assume only a finite number of possible microphases at given temperature, pressure, and volume. H. H. Ho.

SOUND.

409. *Resonance Tubes for Frequency Determinations.* **F. Borrini.** (Archives des Sciences, 1. pp. 541–542, Nov., 1919. Paper read before the Soc. Suisse de Physique.)—Reviews the ordinary use of resonance tubes, open and closed, for the determination of frequencies; and deals with the end corrections. E. H. B.

410. *Propagation of Sound in the Atmosphere.* **G. Green.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 339–352, Oct., 1919.)—It is well known that the transmission of sound through the atmosphere is influenced largely by the conditions of wind and temperature up to considerable heights above the surface of the earth. The general separate effects of wind and temperature gradients are already understood. But the present paper deals with the combined effects of wind and temperature. The paper is illustrated by a number of diagrams, graphs, and tables of numerical results.

It is hoped it will be possible later to discuss the problem in conjunction with careful observations of all significant meteorological conditions.

E. H. B.

411. *Partial Tones of Bowed Strings.* **C. V. Raman.** (Phil. Mag. 38. pp. 573–581, Nov., 1919.)—One of the outstanding questions in the acoustics of the violin family of instruments which has not as yet been fully cleared up, is the manner in which the tones elicited by bowing depend on the position of the bowed "point" on the string. The problem is to some extent complicated by the existence of other variable factors influencing the character of the vibrations excited, *e.g.*, the bowing pressure and speed, and the width of the region of contact between the bow and string. In a recently published monograph [see Abs. 821 (1919)] the author has attempted a systematic treatment of the mechanical theory of bowed stringed instruments. Some of the results of this monograph are here applied to discuss the variation of the amplitudes and phases of the partial vibrations with the position of the bowed point within the range of musical practice. It is found that in the cases under examination, the vibration-curve of a point on the string departs slightly from the Helmholtz two-step zigzag; one of the motions being uniform, and the other fluttering.

From the author's kinematical treatment of the case the amplitudes and phases of the first eight partials have been calculated. The results for the fourth, fifth, sixth, seventh, and eighth are plotted for bowings at from one-fifth to one-ninth of the length of the string. It is seen that the amplitude of a partial is zero for a bowing at its node and that the phase of that partial passes discontinuously from +90° to −90° as the bowing point passes that node. Other, slighter fluctuations occur as the bowing point is farther from the node. E. H. B.

412. *Propagation of Sound in an Irregular Atmosphere.* **G. W. Stewart.** (Phys. Rev. 14. pp. 376–378, Oct., 1919.)—Under poor atmospheric conditions, lower frequencies in aeroplane engine sounds become relatively enhanced; under good conditions, frequencies of the order of 1000 per sec. are heard at greatest distances. The former is explained by irregularities in the atmosphere and the latter by characteristics of audition. It is believed that the intensity of sound varies much more rapidly than as the inverse square of the distance. [See Abs. 861 (1918).] E. H. B.

413. *Mechanical-Acoustical Efficiency of a Telephone.* **W. Hahnemann** and **H. Hecht.** (Ann. d. Physik, 60. 5. pp. 454–480, Nov. 20, 1919.)—In continuation of a previous theoretical paper [see Abs. 1078 (1919)] the authors here describe the development of an experimental method of investigating the efficiency of a telephone as expressed by the ratio of the energy conveyed to the ear to that received by it. This has been determined throughout the range of frequencies concerned with speech (viz., 500 to 1000) with an accuracy of one to ten per thousand. The paper is illustrated by diagrams and graphs of resonance curves and should be consulted by those wishing for such details. E. H. B.

414. *Musical Drums with Harmonic Overtones.* **C. V. Raman** and **S. Kumar.** (Nature, 104. p. 500, Jan. 15, 1920.)—It is well known that percussion instruments as a class give inharmonic overtones, and are thus musically defective. This paper points out that a special type of musical drum has long been known and used in India which forms a remarkable exception to the foregoing rule, as it gives harmonic overtones as in the case of strings. Four such overtones can be elicited beside the fundamental. The arrangement that achieves this end is as follows: The drumhead carries a symmetrical distributed load, decreasing in superficial density from the centre outwards, the load consisting of an adherent flexible composition containing finely-divided iron. This occupies a central circle about the diameter of the drumhead. There is in addition a second membrane in the form of a ring superimposed on the circular membrane round its margin.
E. H. B.

415. *Forced Vibrations of Strings.* **C. V. Raman.** (Phys. Rev. 14. pp. 446–449, Nov., 1919.)—J. A. Fleming modified Melde's experiment, thus rendering it more available for lecture illustration [see Abs. 296 (1914)]. In the present paper improvements on Fleming's modification are described which (1) enable the experimenter to vary the amplitude of the forced vibration, (2) minimise lateral vibration, and (3) make it possible to obtain linear, circular, or elliptical vibrations as desired. This improved apparatus is useful for studying or demonstrating the various types of motion possible for a stretched string. Five photographs illustrate the results obtainable.

The phenomenon observed by A. T. Jones and M. E. Phelps, that when two or more different types of vibration are simultaneously obtained the ratio of the number of ventral segments may differ from the ratio of the frequencies of maintenance is briefly discussed. E. H. B.

416. *Sounds of Splashes.* **C. V. Raman** and **A. Dey.** (Phil. Mag. 39. pp. 145–147, Jan., 1920.)—By means of a special device (due to P. H. Edwards of Washington) the authors have obtained photographic records of the sounds of splashes made when a sphere falls into a liquid. As the late A. M. Worthington showed, the splashes are of two kinds: the smooth or sheath splash, and the rough or basket splash. The former is practically noiseless, but the latter is noisy and violent. Records of each of these are obtained and show very plainly their characteristics. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

417. *Radiation of Electric Waves over a Plane Conductor.* **H. Weyl.** (Ann. d. Physik, 60. 5. pp. 481–500, Nov. 20, 1919.)—Mathematical treatment.
E. H. B.

418. *Symbolic Calculus for Electromagnetic Relativity.* **W. J. Johnston.** (Roy. Soc., Proc. 96. pp. 331–333, Dec. 15, 1919.)—The author, on the basis of some of Clifford's last and perhaps most powerful work, in which he succeeded in combining and thereby extending the ideas of Hamilton and Grassmann, has developed a linear associative algebra remarkably adapted for the direct expression of electromagnetic relativity relations. It is founded on the four fundamental units i, j, k, o, the units being subject only to the conditions $ij=-ji$, $io=-oi$, etc., and the square of each unit being -1. The algebra is therefore one of 16 units, the scalar unit 1 and the 4 fundamental units with their products ij, io, etc., ijk, ijo, etc., $ijko$, each with the factors in a definite order. The scalar unit is commutative with the others, and the remaining 15 units may receive any interpretation, geometrical or otherwise, that is consistent with the distributive and associative principles. For the present application, i, j, k are interpreted as mutually perpendicular unit vectors in Euclidean space, and the unit o as a unit vector in the fourth dimension perpendicular to each of the other three. The several products may remain uninterpreted. Then, as Larmor expresses it in a paper not yet abstracted, the system of invariants natural to a four-dimensional flat continuum are immediately manifest, and the totality of them are identified precisely with the vectors of the electrodynamic scheme of Maxwell, with which they are coextensive. The formal scheme of physical nature, as regards electrodynamic and radiational phenomena, is thus concomitant with the geometry of a single vector infer Euclidean dimensions of space and time.

Larmor summarises Johnson's basis as follows:—The "four-potential," F, G, H, ϕ, recognised by Minkowski, may be expressed by the symbol U, which represents $Fi+Gj+Hk+Wo$; and the usual spacial operator $i\partial/\partial x+j\partial/\partial y+k\partial/\partial z+o\partial/\partial w$ is represented by ∇_1. Then $\sqrt{-1}ct$ is put for w and $\sqrt{-1}\phi/c$ for W; the expression for $\nabla_1 U$ determines the conjoint electric and magnetic fields in terms of his notations, viz., $c\nabla_1 U=jkL+kiM+ijN-\sqrt{-1}(ioX+joY+koZ)$, where XYZ and LMN are the electric and magnetic intensities, the scalar part vanishing in virtue of the electric field being devoid of convergence except at its sources. His expression for $\nabla_1\nabla_1 U$ consists of eight terms as follows: $\nabla_1^2 U=\sqrt{-1}oA-iC-jC'-kC''-\sqrt{-1}(jkoD+kioD'+ijoD'')+ijkB$; and its vanishing involves that of A, B, C, C′, C″, D, D′, D″ separately, giving the eight equations of the electromagnetic field in free space. Thus all is expressed in terms of two vectors, U and ∇_1, in the unitary scheme typified by $i^2=-1$ and $ij=-ji$, but with no other restrictions such as the $ijk=-1$ of quaternions.
G. W. de T.

419. *Bohr's Theory.* **G. Nordström.** (K. Akad. Amsterdam, Proc. 22. No. 2. pp. 145–149, 1919. Comm. No. 48a from the Phys. Lab., Leiden.)—It appears to the author that the usual statement that, according to classical electrodynamics, it is inexplicable why an electron moving in accordance with the quantum condition should not radiate energy, is based upon an insufficiently general assumption. If an otherwise empty space contain electric charges, the electromagnetic field is not singly determined by the Maxwell-Lorentz field equations unless certain boundary conditions are fixed. When this is taken into account, he proves that *every periodic motion of electric charges allows the assumption of an electromagnetic field without radiation of energy.* And this holds even if the motion be not exactly periodic, but consists in, say, a planetary motion with a perihelion movement. This does not appear to resolve the difficulty of Bohr's theory, in that the sudden change from one allowable orbit to another causes difficulties. The change of energy associated with the transition of an electron has quite a different value from what Bohr has to assume, and it does not seem possible to make the two values agree. But the more general conception of the nature of the problem does seem to be of use in obtaining a broader insight into the question as to where the difficulties of Bohr's theory actually lie. G. W. DE T.

420. *An Extension of the Electron Theory of Metals.* I. *Thermo-Electricity and Metallic Conduction.* **A. E. Caswell.** (Phys. Rev. 13. pp. 386–403, June, 1919.)—Using as a starting-point the simple equations deduced from the electron theory by J. J. Thomson and others for thermo e.m.f., thermoelectric power, Peltier e.m.f. and the Thomson-effect, and assuming that the number of free electrons in unit volume of a metal is an exponential function of the temperature, the author shows that (1) The thermoelectric power is a linear function of the temperature; (2) the equations relating thermo e.m.f. and temperature, and Peltier e.m.f. and temperature, represent parabolas having their axes perpendicular to the axis of temperature; and (3) the Thomson effect is different for different metals, and may be either positive or negative, but will usually have a positive temperature coefficient. Likewise, using the equations for electrical and thermal conductivity, and making the second assumption that the number of positive centres with which the electrons collide changes with the temperature (these centres being atoms, molecules, or clusters of molecules), it is found that (4) the electrical conductivity of pure metals decreases with increase of temperature, but is not exactly inversely proportional to the absolute temperature; (5) the peculiar behaviour of the electrical resistance of alloys can be accounted for; and (6) the thermal conductivity may either increase or decrease with the temperature, the temperature coefficient depending both upon the temperature and the material. A third assumption—viz., that the positive centres take part in the conduction of heat, but not of electricity—leads to the conclusion that (7) the usual value deduced for the Wiedemann-Franz-Lorentz ratio is too small, and the variations in the value of this ratio at ordinary temperatures is accounted for. The above theoretical results, especially (1), (2), and (3), are, at least within the ordinary range of temperatures, in substantial agreement with experiment, since the constants involved in the theory can be determined from experimental data, and so the author concludes that (8) the concentration of electrons in a metal is an exponential function of the temperature; and (9) the number of positive centres changes with the temperature, the exact relation being somewhat uncertain. The number, however, must generally increase with the temperature. AUTHOR.

421. *A Critical Thermodynamic Discussion of the Volta, Thermoelectric, and Thermionic Effects.* **P. W. Bridgman.** (Phys. Rev. 14. pp. 306–347, Oct., 1919.)—In this paper the various relations between the Volta-effect, thermoelectric effects, and thermionic effects are critically discussed from the general view point of thermodynamics, avoiding assumptions involving special mechanisms. The ordinary concept of an impressed e.m.f. is found inadequate, and a general definition is proposed, competent to include systems in which the force driving electricity has not the character of a spacially distributed field of force. A thermodynamic proof, dispensing with all special assumptions, is given for a formula for the temperature coefficient of the Volta-effect originally given by Lorentz and Kelvin. This temperature coefficient involves a surface heat the existence of which has not yet been established experimentally, and the possibility of which is usually overlooked. It is shown that Richardson has neglected this surface heat, and that the formula of Lorentz and Kelvin may be deduced also from the phenomena of thermionic emission when the surface heat is taken into account. Formulæ are deduced connecting the latent heat of vaporisation of electrons, surface heat, surface e.m.f., surface potential jump, Thomson heat, e.m.f., and potential gradient. It is shown that in general local heat, potential difference, and e.m.f. cannot be equal to each other. An expression is found from thermionic considerations for the Volta difference of potential between two parts of the same unequally heated metal, and the possibility suggested of using this effect in determining the hypothetical surface heat. It is shown that it is almost certain that in an unequally heated metal there are currents continuously flowing in closed circuits through the metal and the surrounding electron gas. It is shown that the Volta law of tensions must be capable of extension to include the local potential jumps and e.m.f.'s, although these are not susceptible of direct measurement. Finally, expressions are deduced for the effects of pressure and change of state on the Volta contact difference of potential. These involve the change of volume with surface charge and the effect of surface charge on melting pressure, effects for which no search has been made yet experimentally. AUTHOR.

422. *Potentials of Uniform and Heterogeneous Elliptic Cylinders at an External Point.* **N. R. Sen.** (Phil. Mag. 38. pp. 465–479, Oct., 1919.)—The potential of an infinite elliptic cylinder at an external point is generally expressed in the form of an integral, and it is well known that a transformation in conjugate functions would allow the same integral to be represented by a much simpler expression. It is here proposed to express the potential in trigonometrical series. The method followed is that of integration, which is shown to be applicable also in certain cases of heterogeneity.

L. H. W.

423. *Remarks on L. Silberstein's Results in his Paper "On the Dispersion of the Diamond."* **A. C. Crehore.** (Phys. Rev. 14. pp. 440–445, Nov., 1919.)—Silberstein begins with the assumption that dispersion in general is due to the interaction of the electromagnetic field with the electrical charges on the nuclei of atoms. In the particular case of diamond, he deduces from this assumption that the charge on the nucleus of the carbon atom is 2·22 times the electronic charge. He admits that this result is not in harmony with the pan-electronists belief in the indivisibility of the electron. This conclusion justifies us in bringing into question his fundamental premises. It is the author's belief that spectrum effects are in general principally due to the revolving electrons rather than the nuclei of atoms. Reasons for this are given in a book by the author now in the press. In the case of diamond, if

the Silberstein ratio, 2·22, which is corrected to read 2·246, is multiplied by the characteristic number of the tetrahedron, namely 8/3, the result becomes 5·99, which is very close to the whole number 6, the atomic number of carbon. The 8/3 would be required if the effect is due to the revolving electrons. It is pointed out that the dimensions of equations derived from electromagnetic theory by most modern writers are not correct without expressing the specific inductive capacity of the medium. In particular this point is illustrated by Dr. Silberstein's equation (9), and the subject is fully treated in the author's book referred to. AUTHOR.

424. *Some Integrals used in Standardising Electric Units.* **G. Greenhill.** (Roy. Soc., Phil. Trans. 220. pp. 35–65, Dec. 15, 1919.)—The integrals considered are those used by various writers on the theory and accurate use of the V. Jones Ampère Balance and the Lorenz resistance-measuring apparatus of the National Physical Laboratory. They are all here shown to be obtainable by straightforward integration of Maxwell's expression for M, the mutual induction of two parallel coaxial circular currents. The several notations are expressed in accordance with that used by Maxwell, and the mathematical treatment is revised and simplified in such manner as to be adapted for elementary instruction. Considering that the chief analytical and numerical difficulties arise in the elliptic integral of the third kind involved in the use of the ampère balance in its present form, the advisability is suggested, if found practically permissible, of making all the helical coils of the same diameter. This would require the opposition of two coils in axial prolongation instead of one going inside the other. But it would have the advantage of eliminating EI III; so that only EI I and II would be involved, and these are given with extreme accuracy in Legendre's tables. The author observes that the legal definition must be specified with the same precision of language as found in the Act of Parliament on Weights and Measures. G. W. DE T.

425. *Dielectric Constants of Typical Aliphatic and Aromatic Hydrocarbons, cyclo-Hexane, cyclo-Hexanone, and cyclo-Hexanol.* **T. W. Richards** and **J. W. Shipley.** (Am. Chem. Soc., J. 41. pp. 2002–2012, Dec., 1919.)—A modification is described of the Nernst method for measuring dielectric constants, this depending on the comparison of the capacities of a given condenser when air, or standard substance (benzene, ether, toluene), and the substances to be studied are placed successively between the condenser plates. By the use of larger, suitably balanced condenser-troughs, the percentage error of the results is greatly decreased. Values are given for the dielectric constants of 21 organic liquids, mostly hydrocarbons, some of these not having been previously examined. On the average the values for aromatic hydrocarbons are about 20 % higher than those for aliphatic hydrocarbons.

T. H. P.

DISCHARGE AND OSCILLATIONS.

426. *Reflection of Electrons from Metal Surfaces.* **H. M. Dadourian.** (Phys. Rev. 14. pp. 484–489, Nov., 1919.)—A beam of electrons from a hot-lime kathode was introduced into the space between two parallel plates so as to be incident against one of them at a large angle. Then the velocity distribution among the resulting secondary electrons was studied by observing the number of electrons which, overcoming different retarding potentials reached a Faraday cylinder. The experimental results obtained

tend to show that the number of secondary electrons having velocities between zero and a given velocity v may be expressed as the sum of two numbers, one of which is proportional to the number of electrons having the velocity v and the other of which is proportional to the energy of X-rays in the space between the two plates having the wave-length which according to the quantum theory corresponds to the velocity v. AUTHOR.

427. *Photoelectric Properties of Molybdenite.* **W. W. Coblentz** and **H. Kahler.** (Bureau of Standards, Bull. 15, pp. 121–162 [Sci. Papers, No. 338], 1919.)—Gives data on the change in the electrical conductivity of MoS_2 when exposed to radiations of wave-lengths between 360 and 9000 μμ. An effect on the conductivity is produced by wave-lengths below 3000 μμ. Increasing intensity of the light leads to a more rapid response to the longer waves. At room temperatures there are maxima of sensitiveness at 700, 850, 1020, and 1800 μμ. These decrease rapidly on heating, and nearly disappear at 80° C. At $-178°$ C. the whole sensitiveness is higher, with a maximum at 850 μμ. The recovery of conductivity requires a time approximately equal to twice the time of exposure. There is no close connection between photoelectric action and current rectification in molybdenite. It has a high reflecting power in the violet, and a high transmission in the infra-red. This indicates a refractive index of 3 for wave-lengths greater than 1000 μμ. *Molybdenite surfaces polarise light* to some extent. E. E. F.

428. *Resonance and Ionisation Potentials for Argon, Neon, and Helium.* **H. C. Rentschler.** (Phys. Rev. 14. pp. 503–514, Dec., 1919.)—The monatomic gases argon, neon, and helium were tested for resonance potential. The method used was that first described by Tate in his work on mercury vapour [Abs. 1274 (1916)]. As a further check of the results a method similar to that of Lenard was used. Experiments are described which show the necessity of properly freeing the metal electrodes from adsorbed and occluded gases. The results obtained for argon show that the resonance potential is about 12·8 volts and the ionising potential about 17 volts. The value obtained for the ionising potential indicates the shortest argon line to have a wave-length of about 750 Å.U. The results for neon show no indication of a resonance potential. The ionisation potential is about 19·5 volts, not allowing for the initial speed with which the electrons leave the filament. The results for helium again do not indicate a resonance potential. The ionisation potential has a value of about 26 volts. [See Abs. 1278 (1917), 297, 781, and 936 (1919).] A. W.

429. *Transmission of Electric Waves round the Earth.* **B. van der Pol, Jr.** (Phil. Mag. 38. pp. 365–380, Sept., 1919.)—In this paper, written before the communication of Watson's last paper [Abs. 1321 (1919)], the author seeks means of comparing the amplitudes of radiotelegraphic waves to be expected on the diffraction theory, with the observed *normal* values. The daytime measurements, being usually more steady than those obtained during darkness, are taken as *normal*. A critical analytical examination of the results of Nicholson [Abs. 1828 (1910)], Love [Abs. 1109 (1915)], Macdonald [Abs. 1818 (1914)], after correcting an oversight in writing $d/d\theta$ for $d/d\mu$ in his analysis, and Watson [Abs. 206 (1919)], leads to the conclusion that, in the light of the summation by Watson in this paper of the rapidly alternating harmonic series for the amplitude of the magnetic force, they are all in agreement within the limits of their validity as determined by Watson's analysis. All three inves-

tigations, moreover, lead to the conclusion that a finite conductivity of the order of that of sea-water, has only a small influence on the wave-amplitude, increasing it a few per cent. in comparison with the case of infinite conductivity. And Watson obtains a similar result for the conductivity of dry earth. Austin's observations [Abs. 642B (1916)] give amplitudes of as much as two million times the values to be expected from diffraction, and in the author's opinion strongly support the Eccles theory of ionic refraction. With reference to Watson's result that with the assumption of a sharp inner boundary to what Eccles terms the "Heaviside layer" values of the field are obtainable of the order of magnitude of the observations, the author remarks that "roughly speaking, the ionic refraction will amount to the same as if a layer were present in the higher atmosphere which is more or less impermeable to long electric waves, and this may account for the interpretation adopted by some writers, *e.g.*, Watson in his latest paper, of a reflection by a layer of high conductivity. Whether the interpretations in terms of reflection or refraction would differ appreciably will obviously depend on the vertical density gradient of the ions in the upper atmosphere. G. W. DE T.

430. *Perpendicular Passage of Electromagnetic Waves through a Layer of Variable Dielectric Constant.* **J. Wallot.** (Ann. d. Physik, 60. 8. pp. 734–762, Dec. 19, 1919.)—The problem first investigated is whether electromagnetic waves incident on a layer (defined in the paper) are reflected or pass through free from reflection. Different solutions have been arrived at by previous investigators, and, accordingly, the works of Schlick, Rüdenberg, Wallot, Gans, and Emden are briefly discussed. The latter author limits the problem to the perpendicular incidence of rectilinear plane-polarised waves, and concludes that by rapid alteration of refractive index any weakening of the light by reflection within the interior of the layer is excluded. Nevertheless Emden found that by very rapid continuous change of refractive index, total reflection could take place under special circumstances, but not to the extent given by the Fresnel formula. The present author finds that Emden's conclusions are mainly untenable, and that the rays, for a sufficiently high gradient of the dielectric constant, are reflected within the layer, although not to the extent prescribed by the Fresnel formula. Whether the rays are reflected or not, depends only on the ratio of the layer thickness to the wave-length. The paper, which is mainly mathematical, contains a complete account of the derivation of the differential equations, their integration, and discussion of the solution obtained with application to very thin transition layers.

H. H. HO.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

431. *Temperature Coefficient of Resistance of Molybdenum.* **E. C. Blom.** (Phys. Rev. 13. pp. 308–309, April, 1919. Abstract of paper read before the Am. Phys. Soc., March, 1919.)—Some 0·010-in. drawn molybdenum wire was made into lamps and these were run on direct current. For the temperature from 0° to 80° C. the lamps were immersed in a water-bath until constant conditions were reached. The resistance was then measured with a Wheatstone bridge. The temperature was measured with a calibrated thermometer. Over the range 800° to 2000° C. the temperature was measured with both brightness and colour-match optical pyrometers. For the interval 80° to 800° C., the bulbs were removed, and the filaments immersed in a paraffin bath where again the temperature was measured with a calibrated thermo-

V.2
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meter and the resistance measured with the bridge. The interval 300° to 800° C. was not covered, but the results up to 300° and beyond 800° ran so evenly that it is assumed that the curve which fits those temperatures already covered will fit the others also. The following empirical equation was found to yield the correct values:

$$R \times 10^7 = 44 + 0{\cdot}177t + 0{\cdot}000058t^2,$$

where t is in deg. C. and R in ohms-cm. L. H. W.

432. *Rate of Change of Resistivity of Hardened Steel at 100° C. and at Ordinary Temperatures.* **E. D. Campbell.** (Iron and Steel Inst., J. 98. pp. 421–428, 1918.)—The object of the present paper is to furnish some quantitative data on the rate at which the resistivity of hardened steels changes when the steel is reheated to a temperature as low as 100° C., and even when standing at ordinary temperatures, thus furnishing some figures which will indicate the influence of temperature on the rate of reaction in the unstable solid solutions of which hardened steels are composed. The following table shows the effect of reheating for various short periods on the resistivity:

Steel.	H57.	C4.	C5.	C7.
Carbon, per cent.	0·57	0·76	0·945	1·05
Resistivity when quenched from 907° C.	21·88	32·24	36·82	39·73
Resistivity on tempering one hour at 100° to 108° C.	20·67	27·47	29·62	32·97
Resistivity on tempering one additional hour at 100° to 108° C.	20·54	27·47	29·12	32·18
Resistivity on tempering one additional hour at 100° to 108° C.	20·54	27·07	28·89	31·58
Resistivity on tempering three additional hours at 100° to 108° C.	20·27	26·55	28·27	30·32
Resistivity on tempering six additional hours at 100° to 108° C.	19·87	25·75	27·81	29·19
Total drop in resistivity in 12 hours' tempering	2·01	6·50	9·01	10·54

The change of resistivity at ordinary temperatures after two years is only from about 35 % to a little more than 40 % of what it is after twelve hours at 100° C. L. H. W.

433. *Conductivity and Dielectric Coefficient of Dielectrics at High Frequencies.* **G. E. Bairsto.** (Roy. Soc., Proc. 96. pp. 363–382, Jan. 2, 1920.)—Measurements of the a.c. conductivity, dielectric coefficient, and power factor of dry blotting paper, crown glass, vulcanised rubber, gutta-percha, marble, and slate have been made at frequencies from 1000 cycles to 3×10^6 cycles per sec. using a null method. The source of oscillations was an arc generator in an atmosphere of compressed air. Precautions were taken to obtain steady conditions and oscillations of sinoidal wave-form. The voltages used were small enough to ensure the absence of brushing.

The materials under test were built up with tinfoil into condensers of from 300 to 2000 picofarads (micro-mfd.) capacity. The capacity and the loss in the made-up condenser were balanced against an air condenser shunted by a variable high resistance (water). The loss in all the materials examined is due to two factors, namely: hysteresis and viscosity. The hysteresis loss per cycle is constant at low frequencies, but decreases as the frequency is raised: at very high frequencies it tends to vanish; at low frequencies the viscous loss is proportional to the square of the frequency.

The a.c. conductivity and power factor increase with the frequency, and in general they attain maximum values. The max. a.c. conductivity is very much greater than the d.c. conductivity. With glass the ratio is 2500, and with rubber it is greater still. The dielectric coefficient decreases rapidly at audio frequencies, but at a slower rate beyond the audio limit. N. W. M.

434. *Self-Inductance of Coils of Rectangular Section.* II. **A. Esau.** (Jahrb. d. Drahtl. Tele. 14. pp. 386–394, Sept., 1919.)—A formula is derived for the self-inductance of flat coils with square section. Tables and curves are given from which the inductance of such coils can be readily determined. For a given length of wire it is shown that the max. self-induction is obtained when the ratio of winding width to length of side has a value about 0·4. Measurements of the inductance of coils of different dimensions have given good agreement with the values calculated from the formula. [See Abs. 149 (1920).]
A. W.

435. *Self-Inductance of Single-Layer Flat Coils.* **S. Butterworth.** (Phys. Soc., Proc. 32. pp. 31–37; Disc., 37, Dec. 15, 1919.)—The purpose of the present paper was to extend the modified Weinstein formula for coils of rectangular channel section, and to supply a formula suitable for coils of small inner radius. Two formulæ are established for single-layer flat coils, one for the case when the inner and outer radii are not very different, and the other for the case of small inner radius. The two formulæ are shown to be consistent and capable of including all possible cases. From these formulæ the following table is calculated for the factor Q in the formula $L = Qn^2r_2^3$, where n is the number of turns per cm., r_2 the outer radius, and r_1 the inner radius.

r_1/r_2.	Q.	r_1/r_2.	Q.	r_1/r_2.	Q.
0·00	6·970	0·35	5·996	0·70	2·528
0·05	6·964	0·40	5·632	0·75	1·946
0·10	6·930	0·45	5·218	0·80	1·397
0·15	6·845	0·50	4·748	0·85	0·8892
0·20	6·728	0·55	4·231	0·90	0·4574
0·25	6·544	0·60	3·682	0·95	0·1894
0·30	6·300	0·65	3·105	1·00	0·0000

Some applications of the table are given, including the determination of the mutual inductance between coaxial coplanar flat coils. In the *Discussion,* **G. W. O. Howe** pointed out that Spielrein had previously [Abs. 660B (1915)] obtained a formula for the inductance of spirally-wound coils, which can be expressed in a similar form to the formula $Qn^2r_2^3$. When this is done and the value of Q calculated from Spielrein's data, the results agree. Spielrein's table, however, gives results to 7 places for all values of r_1/r_2 from 0 to 1 by steps of 0·01. A. W.

436. *Standards of High Frequency.* **A. Campbell.** (Electrician, 84. p. 66, Jan. 16, 1920.)—In a recent paper a new method for the absolute determination of frequency has been described by A. Dey [see Abs. 1419 (1919)]. He showed that a pendulum of natural frequency about two per second may be maintained in permanent oscillation by an alternating (or interrupted) current of very much higher frequency, when that higher frequency is an exact multiple of that of the pendulum. For example, the ratio of frequencies may be even as high as 140. The present author suggests that this interesting maintenance by higher multiples may be of importance in the standardisation of radio frequencies. It might be possible to maintain a tuning-fork of natural frequency (say) 5000 per sec. by an alternating current of 50,000 or even 500,000 per sec., and thus form a useful check on the other methods of standardising wave-meters. Following Rayleigh's system as used by A. Dey, the magnet coils which carry the high-frequency current, and act on the prongs of the fork, should be placed facing the ends of the prongs so that the magnetic forces they exert on the prongs shall pull longitudinally on them and not tend to deflect them from their positions of rest. If this succeeds we must next think how to excite a *circuit* by a current whose frequency is a multiple of that natural to the circuit. E. H. B.

437. *Laboratory Electrical Measurements by Aid of Variable Condensers.* **C. J. Petropoulos.** (Rev. Gén. d'Él. 6. pp. 881–882, Dec. 18, 1919.)—A description is given of the use of a variable condenser for various laboratory measurements. Instead of using a micrometer spark-gap for determining (with the aid of tables) sparking potentials, a variable condenser may be used as follows: An ordinary spark-gap set to some fixed distance is connected to the terminals of a previously calibrated variable condenser, which is set to its max. value. The condenser is then charged to some known potential and its capacity varied slowly towards zero. The potential across the spark-gap is thus raised, and the reading when the spark occurs readily gives the desired potential. Other uses suggested are (1) for measuring the the p.d. necessary to render a vacuum tube luminous, (2) for graduating direct-reading electrometers. If only the larger values of the variable condenser be used, little error is introduced by neglecting the capacity of any small pieces of apparatus connected to the condenser terminals. A. W.

438. *Application of the Wiedemann-Effect to an Oscillograph.* **K. Tsukuda** and **R. Fujii.** (Phys. Math. Soc. Japan, Proc. 1. pp. 858–856, Nov.–Dec., 1919.)—A nickel wire suspended in a vertical solenoid carries a mirror and inertia bar at its lower end. The solenoid is excited by direct current and alternating current traverses the Ni wire. By the aid of a rotating mirror the wave-form can be examined. The instrument was also used to study the discharge from a Wehnelt interrupter. L. L.

439. *Experimental Method of determining the Primary Current at break in a Magneto.* **N. W. McLachlan.** (Phys. Soc., Proc. 32. pp. 38–52; Disc., 52–53, Dec., 1919.)—In this paper an experimental method of measuring the primary current at break in a magneto is described. A curve showing the relation between secondary peak, voltage, and speed is obtained under running conditions, by the aid of a diode-tube. Since sparks occur at the safety gap when the speed exceeds 80 to 100 revs. per min., it is necessary to reduce the peak voltage by connecting an auxiliary condenser in parallel with the secondary winding or from the h.t. side of the secondary to the frame of the machine. In this way a speed of 2000 revs. per min. can

be attained without the occurrence of sparks at the safety gap. The voltage measured during running consists of two components—(*a*) that due to cessation of the primary current at break; (*b*) that due to rotation. The latter increases with the speed and is approximately 1 volt per revolution, but depends on the type of magneto and the size of the auxiliary condenser.

The peak value of this rotational voltage is found by running the magneto with the primary on open circuit and the secondary connected to the peak voltage measuring apparatus. The open-circuit voltage wave-form, at some convenient speed, is also found. From these two sets of observations, it is possible to obtain the rotational voltages at advance or retard break for any speed. The voltage due solely to cessation of the current is then found by subtracting the rotational voltage from the total secondary peak voltage (curve α).

The rotor of the magneto is fixed in the position at which break occurs during running, and a direct current broken in the armature by means of a separate contact-breaker. The peak voltage due to the cessation of this current is obtained as in the former experiments. In this way a calibration curve showing the relation between current and peak voltage, is obtained. The relationship is very nearly a linear one (curve β).

The current at break when running is found by combining curves α and β. This results in another curve showing the relation between current at break and speed.

Curves are given in the paper showing the relation between the primary current at full advance and full retard up to a speed of 1800 revs. per min. for a B.T.-H. polar inductor magneto. At a certain speed the current is a maximum, the reduction in value beyond this speed being caused chiefly by iron loss.

The effect of the secondary auxiliary condenser on the primary current is examined mathematically and experimentally, and shown to be negligible.
N. W. M.

440. *Application of the Radiometer to the Measurement of Electric Current.* **T. D. Cope.** (Frank. Inst., J. 187. pp. 787–744, June, 1919. El. Rev. 85. pp. 317–318, Sept. 5, 1919.)—Some figures are given showing the sensibility obtained with the author's experimental instrument which is very similar to that of I. Williams [see Abs. 1117 (1918)]. L. H. W.

441. *A Modified Form of Wehnelt Interrupter.* **F. H. Newman.** (Phys. Soc., Proc. 32. p. 54; Disc., 55, Dec. 15, 1919.)—The Wehnelt interrupter is not used generally owing to the rapid disintegration of the platinum wire, and also because the current required for the working of the cell is large. If, however, a modified form is adopted these disadvantages disappear. A plate of Al, area 50 cm.^{2}, takes the place of the lead plate, the other electrode being a Pt wire sealed in a glass tube. These electrodes are immersed in a saturated solution of ammonium phosphate made alkaline with ammonia. This interrupter works equally well with direct or alternating current. In the former case the wire must be made the positive electrode, while with alternating current the passage of the current is such that the wire is positive to the Al. The cell works with a minimum p.d. of 18 volts, but the frequency of the interruptions increases with the applied p.d. The current produced is intermittent, and depends on the surface area of the wire, becoming greater as the surface area increases. Working with a 6-in. induction coil the current in the secondary is very steady and unidirectional, and can be used for X-rays,

or where a steady unidirectional discharge is required for any length of time. No condenser is required nor any make-and-break, and the great advantage is the small current necessary for the working of the interrupter. The secondary discharge is quite steady and of high tension. For the production of unidirectional secondary currents this interrupter works very well, and requires little attention. During the discussion the **Author** stated that any metal would serve, but aluminium was best and required the least voltage.
A. E. G.

442. *Capillary Electrometer.* **P. Barreca.** (N. Cimento, 19. pp. 35–67, Jan., 1920.)—Gives a detailed theory and a description of the mode of action of the capillary electrometer previously described in brief [see Abs. 252 (1917)].
J. W. T. W.

ALTERNATING CURRENTS AND MAGNETISM.

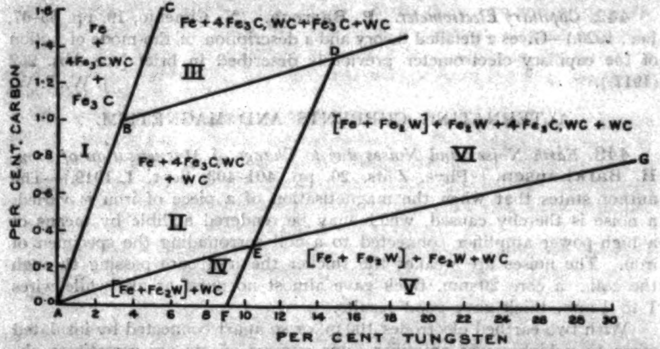
443. *Earth Noises and Noises due to Change of Magnetisation of Iron.* **H. Barkhausen.** (Phys. Zeits. 20. pp. 401–403, Sept. 1, 1919.)—The author states that when the magnetisation of a piece of iron is varied, a noise is thereby caused, which may be rendered audible by means of a high-power amplifier connected to a coil surrounding the specimen of iron. The noises are weaker the thicker the iron core passing through the coil; a core 20 mm. thick gave almost no noise at all, while wires 1 to ½ mm. thick gave good results.

With two earthed electrodes 100 m. or so apart connected by insulated wires to a high-power amplifier some curious effects are sometimes obtained. At times a high-pitched note could be heard in the telephones, and this note would sometimes start at the highest audible limit and range through all frequencies to the lowest audible limits. The phenomenon varied on different days, and is possibly connected with some meteorological effect. The same piping note can be obtained, using two copper electrodes immersed in the sea.
A. W.

444. *Magnetic Analysis as a Means of Studying the Structure of Iron Alloys.* **K. Honda.** (Iron and Steel Inst., J. 98. pp. 375–417; Corres., 418–419, 1918.)—The method of magnetic analysis is based upon the following experimental facts: (1) The intensity of magnetisation of a simple homogeneous ferromagnetic substance in a strong magnetic field decreases, at first slowly and subsequently more and more rapidly, with rise of temperature and finally vanishes at the critical temperature; (2) the critical temperature is a characteristic constant of a ferromagnetic element and independent of external conditions; and (3) an allotropic transformation in a ferromagnetic substance is accompanied by an abrupt change in the magnetisation or magnetic susceptibility. The critical and transformation points of some of the ferromagnetic substances entering into the composition of different kinds of steel are as follows:

Iron	A2 = 790° C.	A3 = 900–910° C.	A4 = 1410–1420° C.
Cobalt	115° C.	Nickel	380° C.
Cementite	215° C.	Iron-tungsten carbide	400° C.
Magnetite	(natural) 580° C.	(chemical) 680° C.	

No appreciable decomposition of cementite occurs on heating up to 400°; at higher temperatures, decomposition does occur but is not complete even at 1000°, 8 % of the cementite resisting decomposition at this temperature. The double carbide of tungsten and iron has its critical point at 400°; in high-tungsten steels decomposition commences on heating at 600° and is complete at 850° C. In the study of carbon steel magnetic analysis gives a method of determining whether or not the cementite exists in the free or dissolved state. Tungsten steels of 53 different compositions have been studied and the results show that these steels can be divided into six classes according to their tungsten and carbon contents, as shown in the accompanying diagram. Classes I and III show three transformations, at 700–770° C., 400° C., and 215° C.; classes II and IV show two transformations, at 700–770° C. and 400° C.; and V and VI, one transformation at 700–770° C. The formula of the double carbide is shown to be $4Fe_3C, WC$. At 770° this double carbide breaks up into its constituents which then dissolve in the austenite, but at about 900° the following reaction begins to take place: $WC + 5Fe \longrightarrow Fe_2W + Fe_3C$ which reaction completes itself at about 1100°. The effects of this reaction on the lowering of Ar1 are discussed, and the work of the author and his collaborators is compared with that of previous investigators. F. C. A. H. L.



445. *Theory of Magnetic Storms.* **F. A. Lindemann.** (Phil. Mag. 38. pp. 669–684, Dec., 1919.)—Chapman's theory attributes magnetic storms to a radial current on the earth, suggesting that the current is provided by beams of α particles, emitted by disturbed areas of the sun's surface, penetrating some distance into the outer envelope of the earth. The present author accepts the idea of radial currents, but from the known dimensions, speed, etc., of α particles, finds that quantitatively Chapman's explanation fails, as other theories, plausible qualitatively, have failed. The author sets out an alternative hypothesis which he considers is possible quantitatively as well as qualitatively. He suggests that approximately equal numbers of positive and negative ions are projected from the sun like a cloud, such as are seen to be emitted in protuberances. The requisite velocity might be acquired by a neutral gas under light-pressure. Such a gas would become ionised under diminishing pressure, and the ions would not recombine on the journey, but the positive ions would penetrate deeper into the earth's atmosphere, allowing of a potential difference of the right order of magnitude. The mass of such a cloud need not exceed $1{\cdot}4 \times 10^{11}$ gm., and its apparent diameter before complete ionisation would be of the order of 1′. He claims that the recombination in the upper atmosphere would account for the radial currents and hence for the magnetic phenomena, just as Chapman's theory does; while not open to the objections he alleges against the α-particle hypothesis that it requires incredible radio-activity in the sun; that electrostatic repulsion would scatter the particles on the way; and that the earth's charge would after a few seconds repel the beam altogether.

W. W. B.

446. *Procedure at the Magnetic Observatories of the United States.* **D. L. Hazard, L. A. Bauer, C. Chree, A. Schmidt.** (Terrest. Magnetism, 24. pp. 145–160, Dec., 1919.)—This series of papers deals with the procedure at (1) the magnetic observatories of the U.S. Coast and Geodetic Survey, (2) the Carnegie Institution observatories. The third paper is a discussion by Chree of the American procedure, while the fourth consists of remarks on magnetogram-scalings and international magnetic data. L. H. W.

447. *The Secular Variation of Terrestrial Magnetism in Siberia.* **B. Weinberg.** (Terrest. Magnetism, 24. pp. 65–86, June, 1919.)—This consists largely of tabulated data unsuitable for brief treatment. L. H. W.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

448. *The Human Body as Electrical Conductor.* **M. Gildemeister.** (Elekt. Zeits. 40. pp. 463–466, Sept. 18, 1919.)—The electrical resistance of the human body varies widely with the method of measurement (whether direct or alternating current is employed) and with the conditions under which the measurement is made, *e.g.*, temperature, state of life, electrolyte employed, duration of current flow, voltage, frequency, wave-form, etc. Using direct current, the resistance appears to decrease with increasing voltage, and (above a certain voltage) with the duration of current flow, after the first thousandths of a second. With alternating current, the resistance shows a leading phase displacement and the apparent resistance to a.c. decreases with increasing frequency and voltage. If the phase displacement be corrected by a self-inductance, the true resistance to a.c. decreases with rising frequency. These phenomena might be explained as a capacity effect, the skin acting as dielectric, but experimental evidence is given in controversion of this hypothesis. It is concluded that the skin is capable of becoming strongly polarised, so that the resistance to d.c. is also an apparent resistance. The true resistance is that measured by high-frequency current and this resistance alone appears to be concerned in electrical accidents. Observations indicate that the skin may be damaged also by moderately heavy currents of long duration. The polarisation capacity of the skin forms, together with a self-induction, a system capable of oscillation and may give rise to resonance.

The surface condition of the skin has naturally a great influence on the effective electrical resistance, hence it is assumed that the skin is freed from grease, by washing with soap or other means, and well saturated with its natural moisture, which generally consists of a weak solution of salt (less than 1%). The resistance offered by the body varies greatly with the size and position of the electrodes. It decreases as the area of the electrode increases, and increases with the distance between the electrodes but not in the same ratio, especially if d.c. or low-frequency a.c. be used for the measurement, because then the resistance is localised principally in the skin.

Although the resistance from hand to hand, as measured by various methods varies over a range of 1100, this variation is very little due to the amount of blood in the skin, the influence of nerves, electro-endosmose, etc. The author states the methods employed and the results obtained in:—(1) Measurements with d.c. (2) Measurements with a.c.: (*a*) neglecting phase displacement, *i.e.*, determining apparent resistance; (*b*) after compensating for phase displacement, *i.e.*, determining true resistance. (3) Simultaneous measurements with both kinds of current.

The polarisation effect may be explained as due to concentration of electrolytes against the membranes which clothe the cells of our skin. A long-continued current causes penetration of electrolyte into the membrane, and thus a reduction in the concentration difference and the e.m.f. of polarisation. After interrupting the current, some time elapses before the original conditions are restored. This explains the apparent decrease in resistance to long-continued d.c., also the "hysteresis" in the relation between current and resistance. The author has observed polarisation e.m.f.'s exceeding 7 volts. The low value of polarisation capacity (0·01 to 0·1 mfd./cm.^{2}), suggests that a number of polarised membranes are connected in series.

It is concluded that the resistance of the human body to voltage dangerous to life is much lower than usually supposed. Further investigations are required, but, in the meantime, the resistance of the body to high-frequency current may be taken as the value of practical importance. In making measurements it is often unnecessary to use electrodes incapable of polarisation because the skin itself is polarised much more strongly than metal. The degree of moisture of the skin is, however, an important consideration. If the skin be dry, there is electrostatic as well as polarisation capacity, and we have then two polarisation cells in series, with a resistance between them and a very small condenser in parallel with the whole. Investigations are still in progress as to the possible increased danger attributable to the fact that the polarisation capacity in conjunction with self-induction may set up resonant oscillations. R. E. N.

449. *Extraction of Foreign Bodies by means of the Radioscopic Screen. Method of Connected Shadows.* **G. Mazérès.** (Archives d'Él. Medicale, 27. pp. 321–328, Nov., 1919.)—The method of connected shadows allows the operation to be made in any direction—vertical, horizontal, or oblique; no special equipment is required, and, thanks to the radioscopic law previously pointed out by the authors, it is no longer necessary to know the direction in which the focus has been displaced, a condition required by all other methods. The radioscopic law indicates the necessary movements. The method here described requires two manipulations, orientation of the forceps and gripping the foreign body; each of these is considered in detail with the aid of diagrams. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

450. *Adsorption of Gases by Charcoal.* II. **H. B. Lemon and K[athryn] Blodgett.** (Phys. Rev. 14. pp. 394–402, Nov., 1919.)—*Problem.*—When an activated and previously evacuated specimen of coconut-shell charcoal is exposed to an excess of a mixture of oxygen and nitrogen, the two gases are unequally adsorbed. It is desired to determine how the equilibrium pressure at constant volume depends upon the composition of the mixture; the ratio of the mass of gas to the mass of charcoal being the same in all cases.

Results.—(1) There is a nearly linear relation between the logarithm of the equilibrium pressure and the percentage of oxygen in the mixture. (2) The two gases in the mixture are not adsorbed independently. (3) A given volume either of a pure gas or of a mixture is less completely adsorbed if admitted at one time than if it is admitted in two portions, the second half being admitted after the adsorption of the first has reached equilibrium. AUTHORS.

451. *Adsorption of Gases at Low and Moderate Concentrations.* I. *Deduction of the Theoretical Adsorption Isostere and Isotherm.* II. *Experimental Verification of the Form of the Theoretical Isosteres and Isotherms.* III. *Experimental Verification of the Constants in the Theoretical Adsorption Isostere.* **A. M. Williams.** (Roy. Soc., Proc. 96. pp. 287–311, Nov. 1, 1919.)—In a previous paper by the author [see Abs. 1260 (1919)] it was pointed out that for small adsorptions the adsorption isotherm could be represented by the simple relation $a = a_0 c$, where a is the amount absorbed and c is the equilibrium concentration outside the adsorbent. The present paper embodies an attempt to evaluate a_0 in the case of gases, and to connect it theoretically with other physical properties. In addition an adsorption formula is developed which applies to gases up to moderate adsorptions, *i.e.*, up to 30 % of the saturation value. The case of a gas at low concentrations is first examined. The assumption is made that upon the surface of the adsorbent there is a certain volume, determined presumably by the range of molecular action, which is occupied by the adsorbate. Then, for the change of energy involved in the adsorption at constant temperature of 1 gm. mol. of the gas by an infinite amount of adsorbent, three expressions may be written:—The first, obtained by the author from thermodynamical reasoning [see Abs. 818 (1918)],

$$E = V\{T(\partial p/\partial T)_a - p\} = RT^2 \partial p/p\partial T - RT = RT^2(\partial \log c/\partial T)_a,$$

where $pV = RT$, and $p = cRT$. A second and well-known expression obtained from the kinetic theory of gases, $E = RT \log V/V_a$, where V_a is the molecular volume of the adsorbate, but which cannot be applied to the case of a liquid and its vapour, owing possibly to the fact that the expression should really be written as, $E = RT \log N_a/N$, where N_a and N are the number of impacts per sec. per unit area by the molecules in the two phases. The third expression is derived by the author from the ordinary theory of attraction, and is the equation for the adsorption isosteres, lines of constant a, namely: $\log a/c = B + A/T$, where A and B are independent of the temperature but are functions of a. Neglecting powers of a beyond the first for moderate adsorptions, this equation becomes that for the adsorption isotherm, $\log a/c = A_0 - A_1 a$, where A_0 and A_1 are functions of the temperature only.

Part II shows to what extent these last equations represent the results of observations, and examines to what degree A and B are independent of temperature and how far powers of a beyond the first may be neglected. Numerous diagrams and tables are included in this section of the paper. Agreement with observation for gases above or near the critical temperature is satisfactory in the case of the adsorption isostere. For the adsorption isotherm, agreement with observation up to moderate adsorptions of gases above their critical temperature is satisfactory. Part III of the paper examines how far the constants of the deduced expressions fall in with their theoretical values, and consideration is limited to the constants A and B of the zero isostere. For this purpose only Miss Homfray's observations are sufficiently extensive to be suitable for the purpose [Zeit. f. Phys. Chem., 74. 129, 1910]. These observations embrace the adsorption by coconut charcoal of helium, argon, nitrogen, carbon monoxide, methane, carbon dioxide, and ethylene, and it has been found possible to evaluate A_0 for all these gases at various temperatures. Accurate extrapolation from the observations was sometimes difficult in the case of the first two gases, which show many irregularities in the data, but was relatively easy with the others. From the numerous tables it is found that A and B are appreciably constant over a range of some 200 deg. C., which indicates that in the temperature region considered, the range of cohesive forces is appreciably constant. This must be interpreted to mean that the molecule is less closely held to the attracting surface at low temperatures. The curves are, therefore, only approximately straight lines, and prediction at present is impossible as to whether they will remain so at higher temperatures. The thickness of the adsorbent is found to be great compared with the adsorption layer. Titoff's observations on hydrogen, nitrogen, and carbon dioxide are utilised at the end of the section [Abs. 549 (1911)]. The conclusions drawn include :—(1) That the relationship among the constants is in good agreement with the theory based on the existence of a thin surface layer. (2) That the range of molecular attraction in the cases considered varies from $8{\cdot}2$ to $4{\cdot}1 \times 10^{-8}$ cm.

A new method is given for obtaining the relative internal cohesion of a gas, and an evaluation is made of the surface area of the adsorbent.

H. H. Ho.

452. *Nature of the Ions Produced by Phosphorus.* **J. A. McClelland** and **P. J. Nolan.** (Roy. Irish Acad., Proc. 35. pp. 1–12, Oct., 1919.)—In previous papers [see Abs. 1264 (1918)] the authors investigated the nature of the ions produced by bubbling air through mercury and alcohol, and discovered many different types of ions. The present work was undertaken to see if any of these groups are formed in the case of ionisation of air drawn over phosphorus. Apparatus similar to that previously described is used. The air is found to contain ions of fourteen types ranging in mobility from 0·22 to 0·000058 cm./sec. in a field of 1 volt/cm., but there is no proof that the largest ion possible has been found. These mobilities do not change with time. Some of the more mobile ions are observed only with dried air and a short time-interval between formation and measurement, some of the slower only with undried air and a long time-interval. They are obtained with both positive and negative charges, and the numbers of each sign are always practically equal. With dried air the ions of higher mobility become more prominent, but the actual mobilities are unchanged.

All except the two slowest classes have been previously discovered, either by bubbling or spraying mercury, alcohol, or water, and the similarity

between these ions suggests that the phosphorus ions, also, are composed of water. It is possible that the original charged nucleus is an oxide of phosphorus with accretion of water similar to those of the other ions.
T. H.

453. *Ozone Form of Hydrogen.* **G. L. Wendt.** (Nat. Acad. Sci., Proc. 5. pp. 518–521, Nov., 1919.)—A summary is given of previous work on the active, ozonic variety of hydrogen [see Abs. 1816 (1917)]. Recent investigations show that this active hydrogen is present in large quantities in any ordinary hydrogen discharge tube, even in a Geissler tube under a pressure as high as 6 cm. That such hydrogen contains no ions is readily shown by passing the gas through a sensitive emanation electroscope, the activity being therefore due to molecules.

The most plausible hypothesis of the mode of formation of the active hydrogen is that the ions collect about them a cluster of molecules yielding a so-called large ion, the valencies in such a group then undergoing disintegration in such a way that the cluster breaks down, giving fragments of various types, among them being H_3 as well as H_2. The existence of such a molecule as H_3 does not accord with the present theories of valency, but it has been shown to be consistent with Bohr's model of the hydrogen atom.
T. H. P.

454. *Atomic Numbers.* **H. Collins.** (Chem. News, 119. pp. 285–287, Dec. 19, 1919.)—The author considers deviations from the "law" that the atomic number of an element is, on the average, rather less than half its atomic weight. He states that the exact truth of the statement is as follows: "When the atomic weight is an even number the atomic number is half the atomic weight, and when the atomic weight is an odd number the atomic number can be obtained by subtracting 1 from the at. wt. and halving the result." There are now only two exceptions: Cl, and N. A. B. W.

455. *An Analysis of the Electron-transference Hypothesis of Chemical Valency and Combination.* **J. Marshall.** (Roy. Soc. Edinburgh, Proc. 39. pp. 209–234, 1918–1919.)—In this paper the author analyses in a tentative way the electron-transference hypothesis of chemical combination which was put forward by Kelvin in his paper, entitled "Aepinus Atomised" [Abs. 861 (1902)], and by J. J. Thomson [Abs. 1343 (1904)]. This hypothesis postulates that on the combination of two or more atoms to form a chemical compound, electrons are transferred from atoms playing an electro-positive part to those playing an electro-negative part in the molecule, the number of electrons thus transferred being taken as a measure of the valencies of the respective atoms in the molecule. Such an hypothesis would not lead to conceptions at variance with the facts of electrolytic dissociation. The methods employed and the assumptions made are similar to those formulated by H. A. Lorentz in his discussion of the Molecular Refractive Index of Mixtures and Compounds ("Theory of Electrons," § 117–130), and by J. J. Thomson in his discussion of the Molecular Refractivity of a collection of atoms [Abs. 1343 (1906)]. Lorentz's discussion ignores the contribution given by the positive electrification of the atom to its atomic refractive index, except in so far as the positive electrification may be the origin of the force which tends to restore a displaced electron to its position of equilibrium, when it is disturbed by the periodic changes in the electromagnetic forces in the ether, when light is incident on the atom. In J. J. Thomson's paper [Abs. 1343 (1906)], the contribution of the positive electrification is not ignored, and the well-known structure of the atom, as a sphere of positive electrification in which negative electrons are situated, is assumed. It is noted that the additive law for atomic refractive indices will follow from any structure assumed for the atom, so long as the actions going on in the separate atoms of a molecule or mixture, are to a large extent mutually independent. If they were not, the refractive index of a compound would be determined principally by the interaction between the atoms, and not as it is actually, by their individual properties.

The assumptions made throughout the present paper are only claimed to be rough approximations to the true state of things, but as they have enabled H. A. Lorentz to deduce the additive law for atomic refractive indices, and J. J. Thomson to give an indication of the discrepancies which might be expected to occur in this law, the author considers that further analysis along similar lines is desirable. Accordingly in Part I of the paper a discussion is given of the value of the atomic refractive index in the case of atoms from which electrons have been transferred, ignoring the contribution to this value arising from fields of electric force due to the vicinity of other atoms or groups of atoms. In Part II a formula is obtained for the molecular refractive index of a diametric molecule, which allows for the contribution due to electrical action between the atoms of the molecule. The method of finding the molecular refractivity of a molecule by the addition of the atomic refractivities of the atoms in the molecule gives very accurate results in the case of organic compounds containing carbon, hydrogen, oxygen, and halogen, provided care is taken to use the values of carbon and oxygen corresponding to their chemical bindings in the molecule. This method is used, therefore, as an aid to the determination of the chemical constitution of organic compounds. In the case of organic compounds containing nitrogen, and in that of inorganic salts, the law does not hold to the same degree of approximation. The present paper discusses, in a very approximate manner, the divergence from the additive law which will arise when the contribution to the molecular refractivity of a diatomic molecule due to electrical action between the atoms in the molecule is taken into account. H. H. Ho.

456. *An Unsolved Problem in the Application of the Quantum Theory to Chemical Reactions.* **W. C. M. Lewis.** (Phil. Mag. 39. pp. 26–31, Jan., 1920.)—In a series of papers, entitled "Studies in Catalysis" [see Abs. 314 (1919) *et ante*], the author has attempted to apply the quantum theory to the problem of chemical kinetics, the fundamental concept being that the thermal radiation in equilibrium with the material system is the source of the energy required to bring about chemical change, and further, that the rate at which a reaction proceeds depends directly upon the density of the radiation of the absorbable type or frequency. By making use of Planck's expression for radiation density, a number of results have been obtained which are in good agreement with experiment. Notably we obtain on this basis for the effect of temperature upon the velocity constant of a reaction an expression which is in good agreement with the empirical equation of Arrhenius, and also with the statistical equation of Marcelin and Rice, namely $d \log k/dT = E/RT^2$, where k is the velocity constant, and E the critical increment reckoned per gm-molecule of the decomposing substance. Having attained a certain measure of success in the case of bimolecular reactions, the attempt is now made to work out an expression for the velocity constant of a unimolecular reaction, based on the quantum theory. There is a fundamental difference between a unimolecular and multimolecular reaction, in that the former represents a spontaneous process independent of collisions with other molecules. It is shown that very different results are obtained according as the continuous or discontinuous view of the absorption of radiation is assumed. On comparing the calculated with the observed velocity constant, a very large discrepancy is found to exist between the two values, this being much greater on the discontinuous view than on the other. The discrepancy is always in the sense that the observed velocity constant is many times greater than the calculated. The discrepancy factor (on the continuous view) is of the order 10^7, and appears to be of the same order of magnitude for different reactions; it also appears to be independent of the temperature. The explanation of this discrepancy would constitute an exceedingly important contribution to the theory of physico-chemical processes. H. H. Ho.

457. *Artificial Production of Diamond.* **C. A. Parsons.** (Roy. Soc., Phil. Trans. 220. pp. 67–107, Dec. 16, 1919. Bakerian Lecture, 1918.)—The full account of the author's experiments [see Abs. 487 (1919)].

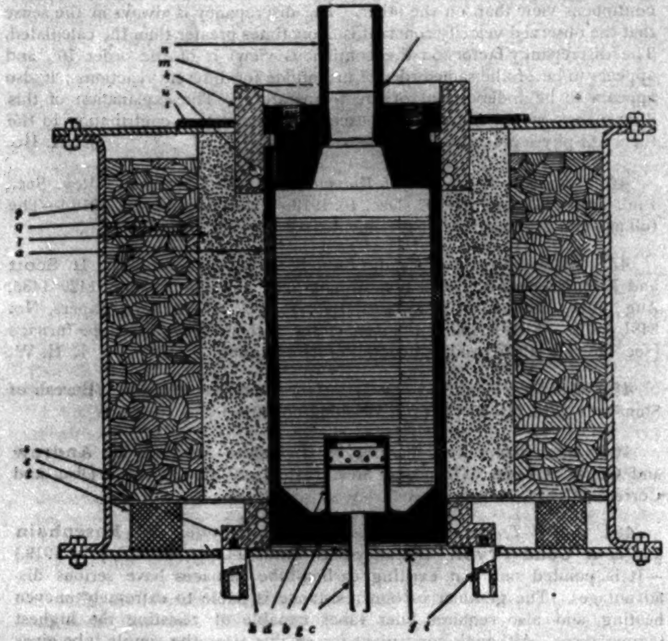
458. *Use of Modified Rosenhain Furnace for Thermal Analysis.* **H. Scott** and **J. R. Freeman.** (Am. Inst. Mining Eng., Bull. No. 152. pp. 1429–1435, Aug., 1919. Bureau of Standards, Bull. 15. pp. 817–828 [Sci. Papers, No. 348], 1919).—A description is given of the author's Rosenhain type furnace [see Abs. 461 (1920)] and an account of its operation. L. H. W.

459. *Bibliography of Scientific Literature Relating to Helium.* (Bureau of Standards, Circ. No. 81 [21 pp.], Washington, 1919.)

460. *Manufacture and Working of High-Speed Steel.* **J. H. Andrew** and **G. W. Green.** (Iron and Steel Inst., J. 99. pp. 305–336; Disc. and Corres., 337–344, 1919.)

461. *A High-Temperature Electric Resistance Furnace.* **W. Rosenhain** and **E. A. Coad-Pryor.** (Faraday Soc., Trans. 14. pp. 264–270, July, 1919.)—It is pointed out that existing carbon-tube furnaces have serious disadvantages. The granular carbon resistance is liable to extremely uneven heating, and also requires liner tubes capable of resisting the highest temperatures. Although convenient for smaller sizes, the simple tube gives much trouble owing to thermal expansion and fragility, and in larger sizes it demands inconveniently large currents. In order to get over these difficulties the device was adopted of forming a tubular heating element by superposing rings of graphite one upon another; this introduces desirable resistance owing to the joints; also the resistance can be regulated by suitably varying the thickness of the individual rings and by varying the total number of rings in a given length of furnace tubing. This adjustment is used not only for regulating the total resistance of each furnace, but also for regulating the distribution of the resistance, and consequently of the heat energy, in different parts of the furnace. The resistance also depends upon the area of contact between successive rings. With increasing size of furnace this area becomes larger and consequently in a large furnace undesirably high currents would be required. This inconvenience can be avoided by reducing the actual area in contact between two rings by grooving the surface of one of them. A further increase in contact resistance can also be produced by altering the quality

of the surfaces in contact, as, for example, by coating them with a small amount of magnesia ; if, however, too much magnesia is used, the furnaces cease to conduct in the cold. Another factor in contact resistance is the pressure between the surfaces in contact. This can be increased or diminished as desired. The general construction of such a furnace is shown in the Fig.



(a) Graphite rings.
(b) Graphite block.
(c) Iron tube, for waste gases,
(d) Pedestal for crucible.
(e) Brass water-cooled electrode.
(f) Steel base plate.
(g) Uralite insulation.
(h) Fibre insulating washers.
(i) Cable sockets.
(j) Graphite tube.
(h) Brass water-cooled electrode.
(l) Plate—of aluminium alloy.
(m) Graphite plug.
(n) Graphite tube.
(o) Joint in graphite tube.
(p) Steel case.
(q) Magnesia blocks.
(r) Vegetable black.
(s) Uralite sheet.
(t) Firebrick support.
(u) Iron tube for water circulation.

Particulars are given in the original paper of the methods employed in order to obtain suitable electrode contact. The steel casing is lined with magnesia blocks, but between these blocks and the graphite rings is a layer of about 8 in. of vegetable black which serves as additional heat insulation and also serves to surround the outside of the graphite rings with an atmosphere rich in carbon. The furnace here described has been found quite satisfactory for a temperature of 1500° C. ; but the ratio of length to diameter is not adequate for really high temperatures. The carbon rings were made by the General Electric Co. of Birmingham: they proved to be somewhat fragile and apt to break in transit, but it has been found possible to work with broken rings. A more serious difficulty is that such rings tend to be converted into graphite locally, where owing to warping local heating takes place. The resulting shrinkage soon leads to failure.

The life of such a furnace depends on the extent to which oxidising gases can be kept away from the heated carbon. In the first furnace so made about 100 heats at temperatures ranging from 1500° to 2400° C. (including fusion of alumina) were obtained in a period of six weeks. Only a few of the rings were seriously burnt by this usage. A furnace 2¾ in. internal diam. attained a temperature of 1500° C. with a consumption of 8 kilovolt-amps. in about 80 minutes and 1700° C. with a consumption of 10 kilovolt-amps., the actual current in the latter case being about 400 amps. with a pressure of approximately 25 volts. If it were desired to heat a plain carbon-tube resistance furnace of the same dimensions to the same temperature, a current of 1500 amps. would be required. W. R. C.

462. *Carburisation of Iron at Low Temperatures.* **A. McCance.** (Iron and Steel Inst., J. 99. pp. 437–441; Corres., 442–446, 1919.)—The variation of the equilibrium conditions in the reactions $2CO = C + CO_2$, $3Fe + 2CO = Fe_3C + CO_2$, $Fe + CO_2 = FeO + CO$ and $3FeO + 5CO = Fe3C + 4CO_2$, are discussed, and curves showing the relation between temperature and the percentage of CO_2 in the gas are plotted. These curves show that at temperatures above 550° C. ferrous oxide is more easily converted into carbide than is pure iron. The work of Carpenter and Smith, and Byrom, is discussed, and it is shown theoretically that blast-furnace gases would be expected to carburise iron at temperatures below 660° C. F. C. A. H. L.

463. *Change of Grain-Size and Grain Linkage in Metals.* **J. Czochralski.** (Zeits. Vereines Deutsch. Ing. 61. pp. 345–351, April 21, 1917.)—The phenomena of the crystallisation of metals are considered in the light of Tammann's work and it is shown that grain-size depends upon the spontaneous power to set up crystallisation nuclei and also upon the linear velocity of crystallisation. A method of determining velocity of crystallisation has been described by the author [Abs. 955 (1919)], depending on a determination of the max. rate at which a continuous crystalline thread can be withdrawn without fracture from its mother-liquor. By this means threads consisting of a single crystal of any predetermined length can be obtained with ease. The crystallisation velocities of Sn, Pb, and Zn in the region of their melting-points are 90, 140, 100 mm. per min. respectively. Grain linkage and crystal direction in a cast metal are associated with the distribution of the lines of heat-flow. Rapid cooling is particularly liable to set up a crystallographically similar arrangement of the crystals (trans-crystallisation), and this manifests itself as one of the commonest casting defects. The changes in grain-size and linkage set up during recrystallisation are considered and solid models illustrating the relations between recrystallisation velocity, number of grains, size and temperature, and degree of deformation are given. Irregular distribution of internal stress is shown to be liable to set up grain linkage. The practical applications of the theories adduced are briefly discussed.

F. C. A. H. L.

464. *On a Spontaneously Oxidisable Form of Aluminium.* **E. Kohn-Abrest.** (Comptes Rendus, 169, pp. 1393–1395, Dec. 29, 1919.) [See Abs.

466 (1920).]—When heated *in vacuo* to 1100° C. aluminium containing 99·8 % Al volatilises and, in the absence of Si and C, such volatilisation is practically complete after 73 hours. At 1200° C. 30 hours only is required. At times, however, part of the metal is less volatile than the rest, the residue then being spontaneously oxidisable in air. A tube of iron was covered with a coating of the volatilised aluminium which tarnishes in air but remains bright when air is excluded. The residue, which must be heated for at least 16 hours at 1100° C. to be spontaneously oxidisable, falls to a voluminous yellowish-grey powder consisting of particles of metal and oxide. One sample of such residue contained 0·40 % iron and 0·58 % silicon. It is not possible to ascribe the peculiar properties to these impurities, and for want of a better explanation the change effected is ascribed to an allotropic transformation. F. C. T.

465. *Critical Points of Self-hardening Steels.* **P. Dejean.** (Comptes Rendus, 169. pp. 1043–1045, Dec. 1, 1919.)—A nickel-chrome-copper steel of the following composition: 0·39 % C, 0·23 % Si, 0·43 % Mn, 2·44 % Ni, 1·83 % Cr, 1·73 % Cu, was cooled from different temperatures, in all cases taking 150 minutes to fall from 700° to 100° C. In the case of treatment which renders the steel pearlitic or troostitic the carbon change-point A occurs above 600° C., while when the structure is martensitic a low-temperature point B is observed. When the initial temperature of cooling is 790° C. the point A is observed alone. A second point B, about 420° C. is observed in addition to A on cooling from 800° C., which point gradually replaces A as the cooling temperature is raised. Cooled from 850° C. a second point B_2 also makes its appearance at 230° C. At higher temperatures B_1 disappears, only B_2 being found. The point B_2 still persists with more rapid cooling. The appearance of the point B_2 results in a marked increase of the hardness of the specimen The max. hardness which can be conferred on this steel by quenching is attained in two stages corresponding to two labile equilibria characterised by B_1 and B_2. When B_2 is present the structure of the steel is martensitic; the martensite, however, is harder and less easily attacked by picric acid than that due to B_1. [See Abs. 1318 (1917).] F. C. T.

466. *Transformations of certain Alloys of Aluminium.* **L. Guillet.** (Comptes Rendus, 169. pp. 1042–1043, Dec. 1, 1919.)—When prepared by the aluminothermic process the following alloys of aluminium rapidly fall to powder: 65–95 % Fe, 80–90 % Mn, and 50–80 % Ni. Prepared, however, by direct fusion alloys containing 77·55 % Fe and 62·52 % Ni respectively do not disintegrate, though an alloy with 85·4 % Mn did do so in 7 days in air and in 15 days in currents of oxygen, nitrogen, or hydrogen. No appreciable change of weight occurs, the crumbling of the Al-Mn being attributed to a polymorphic change. In the case of an Al-Sb alloy with 79·86% Sb, this fell to powder in four months in the open air, but showed no change in dry air, oxygen, nitrogen, or hydrogen. This alloy is considered to disintegrate simply as a result of oxidation. [See Abs. 178 (1920).] F. C. T.

467. *Cooling Properties of Technical Quenching Liquids.* **N. B. Pilling** and **T. D. Lynch.** (Am. Inst. Mining Eng., Bull. No. 153. pp. 2347–2367, Sept., 1919.)—A special apparatus has been designed for taking autographic cooling curves of standard specimens during quenching from 880°, and by its aid a systematic examination of the quenching properties of water, 24 %

V.2
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NaCl solution, 2 % soap solution, three mineral oils having flash-points of 188°, 204°, and 305° C. respectively and concentrated sulphuric acid has been made. The transfer of heat during quenching is effected in three stages: A—slow cooling in vapour, B—rapid cooling by active vaporisation, and C—slow cooling in the liquid. Indications that the division of the quenching action into steps and that the temperatures limiting them are independent of the size of the object have been obtained. The quenching power of a liquid is defined as ability to absorb heat rapidly and its evaluation in absolute units is difficult, so that cooling velocity in degrees per sec. has been taken as a measurement of the quenching power. In water at 0° C. the B stage of cooling takes place from the initial temperature of quenching downwards, but as the temperature of the quenching water increases the A stage commencing at 39° C. becomes more and more prolonged and passes over into the B stage at lower temperatures. The A stage does not occur in brine until the quenching liquid has a temperature of 60° C. In soap solution the A stage is prominent at 20° C. The three oils show a marked difference in behaviour. With sulphuric acid, quenching commences in the B stage at all temperatures of quenching liquid up to 118°, and in every case the transition to the C stage occurs at about 400°. Taking as unity the quenching power of an aqueous liquid at 100°, then the relative value of the quenching powers of the different liquids at 20° are: Water, 11; brine, 20; soap solution, 1·8; oil No. 1, 2·5; oil No. 2, 2·0; oil No. 3, 10·0; and sulphuric acid, 24. In each case comparisons are made of the cooling velocities when the standard cylinder has attained a temperature of 700° C. F. C. A. H. L.

468. *Admiralty Gun-metal.* **F. Johnson.** (Inst. of Metals, J. 20. pp. 167–179; Disc., 180–195, 1918. Engineering, 106. pp. 330–332, Sept. 20, 1918.)—Deals with the influence of impurities on the mechanical properties of this alloy. The main results from the author's own experiments are summarised as follows:—1. From the point of view of mechanical properties, the results given by arsenic and antimony are not in accord with the views of other metallurgists. 2. Nickel has a decidedly beneficial effect in Series I, whilst in Series II (more drastic chilling) a remarkable increase in ductility is obtained. 3. Lead does not appear seriously to affect the mechanical properties, although it is possible the resistance to shock is lessened. 4. Iron has a beneficial influence on mechanical properties, the yield point, tensile stress, and elongation all being raised. Its effect on pouring qualities is bad, but much improvement is effected in this respect by the addition of a trace of aluminium. 5. The influence of manganese is bad in every way, the mechanical properties being adversely affected and the pouring qualities also. The surfaces of the castings were bad. 6. The annealing treatment goes far towards eliminating ill-effects produced by undesirable additions, notably aluminium and silicon. The general improvement brought about by annealing is remarkable. L. H. W.

469. *Viscosity of Steel at High Temperatures.* **P. Chevenard.** (Comptes Rendus, 169. pp. 712–715, Oct. 27, 1919.)—A photographic record is taken of the viscous elongation of a loaded wire heated in an atmosphere of nitrogen. The rapidity of extension $1/L_0 \cdot \partial L/\partial t$ gradually decreases, the curve tending to attain a constant inclination corresponding to a constant speed of extension v under constant load. This speed increases rapidly above 500–600° C. at which temperature rapid disappearance of internal stresses should occur.

If $t^{p_1}_{p_0}$ is the time of annealing required to reduce the internal tension from p_0 to p_1, $t^{p_1}_{p_0} = \frac{1}{E}\int_{p_0}^{p_1} \cdot \frac{dp}{v}$. For a nickel-chrome steel (C 0·8 %, Ni 4·2 %, Cr 1·6 %) annealed and air-hardened from 700° C. the following results are given for the time required for the tension to fall from 10 kg./mm.^{2} to 1 kg./mm.^{2}

Temperature.	Time in secs.	
	Annealed.	Air-hardened.
550° C.	1020	—
600	200	250
650	74	84
700	88	88

For all steel, with the exception of high-speed steels, and annealing for a few hours at 600–700° C. will practically eliminate all internal stresses.

F. C. T.

470. *Study of the Influence of Different Factors on the Creation of Longitudinal Internal Stresses arising from the Rapid Cooling of Cylinders of Steel.* **M. Portevin.** (Comptes Rendus, 169. pp. 955–957, Nov. 24, 1919.)—The quenching of steel bars at temperatures below 200° C. results in no internal straining. Between 200° and 600° the internal stresses set up are appreciable and increase fairly rapidly as the temperature of the quenching is raised. The quenched bar is under compression at the surface and under tension on the axis. The internal stresses arising from quenching in oil are only 0·5 to 0·25 of those due to water-quenching. In the case of hardening in water the resulting internal stresses decrease as the temperature of the water rises, becoming sensibly nil at 100° C. As the duration of the immersion in the quenching medium is increased the internal stresses also rise. The greater the diameter of the bar quenched, the lower are the stresses set up; the results, however, show considerable discrepancies. The quenchings carried out for the purpose of this work were all made at 650° C., *i.e.*, below the A1 point, since Heyn and Bauer's method of measuring the internal stresses does not lend itself to test on the fully hardened steels. It is considered that since the viscosity of the steel at higher temperature than that used is lower, the internal stresses due to full hardening are not likely to be much greater.

F. C. T.

471. *The Reaction between CO and Electrolytic Iron below the A1 Point.* **H. C. H. Carpenter** and **C. C. Smith.** (Iron and Steel Inst., J. 98. pp. 189–191; Disc. and Corres., 192–197, 1918.)—In view of the fact that the experimental data obtained in the research bear witness to the complexity of the reactions which may occur by the interaction of pure iron and pure CO at 650° C., it has not been possible to reach a conclusion as to the precise chemical change or changes that take place under the conditions investigated. It has, however, been demonstrated:

1. That the action of pure carbon monoxide on pure iron below the A1 inversion gives rise under certain conditions to a substance, x, which is almost certainly a carbide of iron.

2. That the presence of sufficient carbon dioxide in the gas completely removes or inhibits the formation of *x*.

3. That the addition of hydrogen to CO favours the production of *x* by preventing the formation of a solid oxide phase.

4. That the micrographic and chemical characteristics of *x* are very similar to those of cementite, Fe_3C, in particular to the form of cementite obtained by Byrom (and identified by Stead) by the action of blast-furnace gas on pure iron, wrought iron, and mild steel.

5. That by the reaction between CO and iron at 650° C. carbonaceous products are formed in the majority of cases, containing iron, carbon, and oxygen.

It may also be stated that the formation of a carbide of iron, if carbide it is, in the above experiments below A1, is perfectly consistent with the widely accepted opinion that free iron and free carbon are the stable phases of the iron-carbon equilibrium in this temperature range. AUTHORS.

472. *Improvements in the Case-hardening Process.* **D. Hanson** and **J. E. Hurst.** (Iron and Steel Inst., J. 99. pp. 383–401; Disc. and Corres., 402–405, 1919.)—The authors summarise their results as follows :—

1. Ordinary methods of case-hardening at or above 900° C. tend to lead to the formation of a hyper-eutectoid layer in the case, which is a frequent source of flaking and grinding cracks.

2. In nickel case-hardening steel containing up to 3½ % of Ni, the practice or refining at a temperature lower than the carburising temperature tends to aggravate this trouble.

3. Trouble from this cause may be avoided by : (*a*) Quenching the steel from a temperature at which the excess of carbide is dissolved. (*b*) Modifying the treatment during carburising in such a manner that a case of practically eutectoid composition is obtained.

4. Of these methods (*b*) is to be preferred.

5. A simple modification of existing practice has been suggested by means of which this can be effected.

6. Experimental evidence and an account of the successful working of the process on a works scale have been given.

7. For 5 % nickel steels a high carburising temperature appears to be satisfactory. L. H. W.

473. *Macro-etching and Macro-printing.* **J. C. W. Humfrey.** (Iron and Steel Inst., J. 99. pp. 273–286 ; Disc. and Corres., 287–808, 1919.)—Deals with the two methods available for revealing the macrostructure of steel—namely, (1) sulphur printing, and (2) etching. The way in which these methods are carried out is described at length, and some prints are reproduced as examples and further discussed. L. H. W.

474. *Electrolytic Resistance Method for determining Carbon in Steel.* **J. R. Cain** and **L. C. Maxwell.** (Bureau of Standards, Technol. Papers No. 141 [21 pp.], Washington, 1919.)—1. Describes the fundamental principles of a method for determining carbon dioxide by absorbing it in barium hydroxide solution and measuring the resistance change of the solution in relation to its concentration.

2. Special resistance-measuring apparatus was developed which simplified the measurements by dispensing with tuned telephones, high-frequency generators, and balanced inductances and capacities.

3. A convenient nomographic method of applying necessary temperature corrections to resistance measurements was developed.

4. The method permits of accurate determinations of carbon in steel (*i.e.*, within 0·01 % carbon) by the direct-combustion method in 4½ to 5 minutes.

L. H. W.

475. *Studies in Conductivity.* V. *Notes on the Measurement of the Conductivity of Solutions.* **H. I. Schlesinger** and **F. H. Reed.** (Am. Chem. Soc., J. 41. pp. 1727–1732, Nov., 1919.)—It is pointed out by the authors that even though the minima obtained in the measurement of the resistance of solutions by the usual method may be perfectly sharp, the results may nevertheless be incorrect. Criteria for determining the reliability of the measurements are given, and methods for overcoming some of the difficulties encountered, and which have not been referred to by Washburn and his associates [see Abs. 437 (1917)] are suggested. The resistance of the solutions used by the authors was measured by the Wheatstone-Kohlrausch method, using a Siemens and Halske high-frequency generator, a rotary bridge, and a standardised Curtis coil resistance-box. In conjunction with the high-frequency circuit a Leeds and Northrup condenser was used, which permits of placing equal capacities in series with the two lines of the circuit; by means of a two-way switch this condenser could be eliminated and readings taken without any capacity in the high-frequency circuit. It was observed that the introduction of the condenser, while it improved the sharpness of the minimum, decidedly shifted its position and that the shift thus produced depended on the type of resisting medium and the magnitude of the resistance. The shift was particularly large with the usual Wheatstone bridge set-up, that is, with the current entering at the ends of the bridge. The shift could be completely eliminated by having capacities in the two sides of the circuit which were not identical, but it was found that the best method was to have the telephone at the ends of the slide wire. With this latter method, when the capacities in the high-frequency circuit were 0·0245 and 0·0225 respectively, instead of being equal, the introduction of the condenser into the circuit did not produce any shift in the minimum and gave the correct reading for every type and value of resistance measured.

There is another source of possible error in measuring resistances which has not received the attention which it deserves in the treatment of the subject. It is important that the cell constant should be the same, no matter what standard solution is used to determine it. The standard solution used to determine the cell constant should have, in the cell, a range of resistance completely covering the range of the solutions to be measured in it. That this is not usually understood is demonstrated by the fact that the specific conductivities determined by Kohlrausch, which are usually employed as standards for the determination of cell constants, are not well enough distributed to cover satisfactorily every possible range of resistance. T. S. P.

476. *The Free Energy of Dilution of Aqueous Sodium Chloride Solutions.* **A. J. Allmand** and **W. G. Polack.** (Chem. Soc. J., Trans. 115. pp. 1020–1039, Sept., 1919.)—The authors have carried out measurements of cells of the type Hg | Hg_2Cl_2 aqueous NaCl solutions | sodium amalgam at 18° and 25° for concentrations of sodium chloride ranging from between 0·01 N and saturated solution. From these measurements they have calculated the free and total energies of dilution of sodium chloride between the above concentration limits. From the determinations of e.m.f. the authors have also calculated the transport number of the sodium ion in different dilute sodium chloride solutions, and also the molecular heat of solution of sodium chloride in saturated solution at 18°. Calculations have also been made of the free and total energies of the reactions $2Na + Hg_2Cl_2 \longrightarrow 2NaCl$ (solid) $+ 2Hg$ and $2Na + Cl_2$ (1 atmo.) $\longrightarrow 2NaCl$ (solid); of the free energies of one molecule of sodium chloride in aqueous solution at various concentrations at 18° and 25°, referred to the free energies of the elements sodium and chlorine as zero; of the "thermodynamic degrees of dissociation" of sodium chloride in aqueous solution at different concentrations at 25°, and of the corresponding activities of the sodium ion. The apparently abnormal molecular condition of sodium in sodium amalgams has been confirmed.

A. F.

477. *Present Position of the Theory of Ionisation. A General Discussion.* (Faraday Soc., Trans. 15. pp. 3–163; Disc., 164–178, Dec., 1919.)—After an introductory address by **G. Senter** the following papers were read as contributions:—"Electrolytic Dissociation," by **S. Arrhenius**; "Reactions of both the Ions and Molecules of Acids, Bases, and Salts," by **S. F. Acree**; "Determination of the Ionisation of an Aqueous Solution" and "Correction of the Transference Numbers of the Ions of an Electrolyte," by **W. R. Bousfield**; "Some Aspects of the Electrolytic Dissociation Theory," by **N. R. Dhar**; "Hydration of Ions," by **H. J. S. Sand**; "Recent Investigations on the Dilution Law," by **J. R. Partington**; "Variation of Electrical Conductivity of Electrolytes with Increase in Concentration," by **A. W. Porter**; "Resistance of an Electrolytic Cell," by **E. Newbery**; "Effect of Interionic Forces in Electrolytes," by **S. R. Milner**; "Ionisation and the Mass Law," by **H. M. Dawson**; "Abnormality of Strong Electrolytes," by **J. C. Ghosh**.

478. *Potentials of the Zinc and Cadmium Electrodes.* **W. G. Horsch.** (Am. Chem. Soc., J. 41. pp. 1787–1800, Nov., 1919.)—In previous work by the author mercurous sulphate was used in the reference electrode. Owing to its unsatisfactory nature other insoluble sulphates have been tried, but none of them was found to be suitable. Consequently, in order to determine the potentials of the zinc and cadmium electrodes the following cells have been measured: $Zn : ZnCl_2 : AgCl : Ag$; Cd (amalgam) $: CdCl_2 : AgCl : Ag$; Cd (amalgam) $: CdCl_2 : Cd$; $H_2 : HCl(0{\cdot}01m) : AgCl : Ag$. In the first cell the concentrations of the zinc chloride solutions ranged from 0·0008 *m* up to 0·01 *m*. In the second, the concentrations of cadmium chloride ranged from 0·0001 *m* up to saturation (6·61 *m*). All measurements were carried out at 25°. The normal electrode potentials of zinc and cadmium were found to be: zinc, 0·758 ± 0·002 volt; cadmium, 0·3992 ± 0·0010 volt, the normal potential of the hydrogen electrode being taken as zero. From the results the free energy of dilution of zinc and cadmium chlorides solutions at various concentrations are calculated.

T. S. P.

479. *Concentrated Thallium Amalgams: Their Electrochemical and Thermochemical Behaviour, Densities, and Freezing-points.* **T. W. Richards** and **F. Daniels.** (Am. Chem. Soc., J. 41. pp. 1732–1768, Nov., 1919.)—The electromotive forces between thallium amalgams ranging from 0·88 % to saturation (over 40 %) have been measured within a few microvolts, at 20°, 30°, and 40°, and are found to be greater than those demanded by the simple concentration law. The temperature coefficients of the e.m.f. calculated from these results are less than is required by the gas law, and vary as the concentration increases. The densities of the liquid amalgams and the solution volume of thallium in mercury were determined over the whole range. The solution volume is found to be remarkably constant, varying only from 17·47 to 17·51, but it is somewhat in excess of the specific volume of Tl, namely, 17·21. It follows that thallium expands on amalgamation. The coefficients of expansion of the various amalgams, calculated from their densities, were found to diminish with increasing concentration. The heat capacities of the amalgams were determined by introducing a known quantity of heat, by means of an electrically heated coil, into a weighed amount of the amalgam, and observing the rise in temperature. They were found to be distinctly in excess of the sum of the heat capacities of the thallium and mercury taken separately; that is, the "solution heat capacity" of 1 gm. of dissolved Tl is greater than the heat capacity of 1 gm. of solid Tl. This excess is greater in dilute than in concentrated amalgams. The heats of dilution of thallium amalgams with mercury at 20° were determined over the whole range of concentrations, and with the help of the heat-capacity values these results were corrected to 80°. The heats of solution of thallium in mercury and in Tl amalgams of increasing concentration were also measured. It is further shown that, within the limit of error of experiment, the heat effects in the cells of which the e.m.f.'s were measured may be calculated from either the heat of dilution of the amalgams, or from the heat of solution of Tl in the amalgams, or from the temperature coefficient of the e.m.f. (Helmholtz equation). Each of these three methods gives identical results within the limit of error of the experiment. The freezing-points of the amalgams from 16 to 45 atomic % were repeatedly determined, and were found to give a curve indicating conclusively the existence of the solid compound Tl_2Hg_5, melting at 14·9°. The single potential of pure electrolytic Tl was found to be about 2·5 millivolts more negative than that of the saturated Tl amalgam at room temperature. T. S. P.

480. *Potential necessary for the Electrolysis of Solutions of Iron.* **W. A. Noyes, Jr.** (Comptes Rendus, 169. pp. 971–978, Nov. 24, 1919.)—The minimum potential necessary for the electrolysis of a solution of a ferrous salt between electrodes of electrolytic iron is 0·66 volt at 20°; this value diminishes 0·007 volt for each degree rise in temperature up to 110°, when it attains a maximum, and rises again with further rise in temperature. T. S. P.

481. *Passivity of Cobalt.* **H. G. Byers** and **C. W. Thing.** (Am. Chem. Soc., J. 41. pp. 1902–1908, Dec., 1919.)—In 0·2N-H_2SO_4 solution at 0° a cobalt anode becomes passive at a current density of 16–17 amps./dm.^{2}, and it then remains passive at the lower current densities of 5·5 and 4·6 amps./dm.^{2} respectively. In 0·2N-Na_2SO_4 solution cobalt also becomes passive at high current densities. In potassium dichromate solutions Co assumes the passive state under all conditions, but the addition of sulphuric acid or sodium sulphate may render the cobalt active again. The passive state is indicated by an increased voltage drop, a decreased current, by the evolution of oxygen gas, and by the failure of the anode to go into solution. Measurements of the anodic potential show that when the metal is active and no current is flowing it has a negative potential. When current is passing, the potential changes in sign and increases in value, even if the metal remains active. If, however, the metal becomes passive, the potential is markedly increased. [See Abs. 2065 (1908).] T. S. P.